POWER PLANT ENGINEERING

CONTENTS FOR THE MONTH OF

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FASHION NOTE

GREEN AND YELLOW changeable rayon taffeta with dainty lemon yellow jacquard flowers is used for this smart portrait evening dress. It is truly a frock of distinction, one which should intrigue the fancy of every woman's heart for it is the only one of its kind in the world. The loosely fitted bodice has small draped sleeves and a plain square neck, accentuated by the model with a double string of pearls. The skirt is stiffly full, flaring wide at the bottom but with a closely fitted waistline and rippling with lovely stainless steel turbine blades, a motif symbolizing the age of power. The blades were designed exclusively for this gown by Jee Eigh. They are delicately fashioned out of the most exquisite materials (11.5-13% Cr., 0.10 to 0.15% C) with an ultimate strength of 90,000 to 100,000 lb. per sq. in. and with an elastic limit of 60,000 to 70,000 lb. per sq. in. Narrow at the waistline, the blades flare wide at the bottom giving emphasis to the sweep of the skirt. The whole effect is one of abandon just short of the exotic but capturing at the same time the old fashioned charm of the hoop skirt. The serrated edge is at once practical and artistic. Machined to tolerances within 0.0001 inch, the serrations provide a foundation well fitted to withstand the centrifugal force under high temperatures to which the blades will be subjected. The loveliness of these ornaments is exceeded only by their cost. Jee Eigh informs us that the cost of this chic frock is around $5000 which makes the blades about $250 apiece—somewhat high perhaps but not for an 80,000 kw. baby.

WITH THE EDITORS

Use Up-to-Date Ideas

RECENTLY a friend who knew what was being prepared for the January, 1940, issue on engineering progress during the last decade asked the blunt question, "What use can the reader make of this material?" Now that is a fair question, and, if it lurks unanswered in the mind of an engineer who has read these pages,—if none of the data has inspired an effort to improve his plant and its performance, then the mark aimed at in preparation of the issue has been missed.

To guard against such a result, these suggestions are put forth:

While authors have necessarily dealt with progress in general terms and the problems in any plant are individual to it, the reader may well watch for applications of such matters as progress in metals to his own problems. If welded pipe joints are bothering, the answer may be in Mr. Kanter's statement that, "It has been necessary to limit carbon content of all grades of steel used in welded fabrication."

Comparatively few industrial plants are using regenerative and reheat cycles, and bleeding steam for industrial use would often give a saving over the use of reduced-pressure live steam. Are there possibilities in your plant?

New equipment which has proved its worth but may have needed perfecting in some details has made obsolete a surprisingly large proportion of power plant equipment during the past 10 yr. Compare your present equipment with that described in these pages. You may be surprised; first at how far it falls behind present best practice; second at how simply some of it can be brought up to present standards of performance by changing some parts or the arrangement of the plant.

After reading the issue, why not designedly list all the obsolete features of your plant, equipment and arrangement that is expensive in upkeep or below standard in performance, as compared to new equipment and methods of operation. Grouping equipment into main units and the auxiliaries that serve them will facilitate the study of the advantages of replacement or rehabilitation and their cost.

After study of what should be replaced, what rehabilitated and what discarded, with economic improvement from the changes, a resumé should be made of cost of operation and power production with the present plant, and with the revised plant. This should be reduced to details, and an alternative plan of partial renovation and its benefits also worked out.

When you have made the engineering decision as to what is desirable, the possible savings should be reduced to dollars and cents, with the income on the required investment shown and the time required to pay for the changes by savings effected. You are then ready to present your case to the owner of the plant and show him why the changes proposed are good business.

In order to be a little more specific in these suggestions the following example is presented as being typical of those comparing present equipment with that which is proposed. The data on present equipment can be secured from the plant records or, lacking these, calculated from tests conducted for the purpose. Manufacturers can supply the data for the proposed equipment. In this particular problem it is assumed that coal of a higher heat value and price is used because the present burning equipment cannot use the lower grade coal. The proposed equipment would make this possible. Assuming exactly the same furnace and boiler efficiency, which is giving present equipment the advantage, more tons of the lower grade coal will be required. The price differential may be optimistic but the method employed for making the economic comparison is readily followed. This is the way the problem works out:

	Present	Proposed
Coal fired per year, tons	3,937	4,575
Heat value of coal, B.t.u. per lb.	12,046	10,689
Cost of coal per ton	$4.50	$3.53
Total cost of coal fired	$17,716.50	$16,149.75
Investment cost of burning equipment including installation	$ 3,000.00	$ 4,150.00
Annual Expenses:		
Depreciation, assuming 10 yr. life—present equipment written off	0	$415.00
Interest on investment, at 4% (average)	0	$89.00
Repairs and Maintenance:		
Present equipment from records	$480.00	
Proposed 2% of first cost		$83.00
Power for driving	$984.25	$1,145.00
Labor	$4,000.00	$4,000.00
Fuel costs	$17,716.50	$16,149.75
Total annual expenses	$23,780.75	$21,881.75
Savings Effected per Year:		
Savings ($23,180.75—21,881.75		$1,299.00
Reduction in costs, ($2,329.50÷1,299.00×100)		5.60%
Net annual return on investment (2,329.50÷4,159.00×100)		31.3%
Equipment pays for itself in less than 39 months.		

Nearly every problem of this sort involves intangibles that do not show up in an economic statement and it is always well to bring these into the discussion. In this particular problem for instance, the amount of smoke and fly ash, if the location of the plant is in a city, may be a deciding factor.

In this issue it is shown power generation can be accomplished at less cost per unit than was possible 10 yr. ago; also the changes in equipment and methods that have brought about this result.

Your plant has its individual problems, but there can be little doubt that it can be substantially improved by applications of the advances explained by the various authors of articles. It is true that in many if not most plants, obsolete equipment even as a gift can not be profitably operated as compared with results from modern equipment bought at market prices. Up-to-date ideas will pay handsome returns, if you use them.

MORE

DESIGNED for operation at 800 lb. per sq in., 900 deg. steam temperature and with its 3600 r.p.m. hydrogen-cooled generator the 35,000-kw. Westinghouse turbine-generator at New Castle is in many ways a measure of progress in the power industry during the past decade—a summing up, for it contains nearly all the features of modern development that were non-existent ten years ago. In 1930 there were no hydrogen-cooled generators. Machines running at 3600 r.p.m. larger than 15,000 kw. capacity still had to be built, in fact the 18,750-kw. units built the following year were, then, the largest units of that speed ever built in this country. Steam temperatures of 900 degrees were being experimented with but no such temperatures were in commercial use in power stations. Today, all these things are relatively common. Thirty six hundred revolutions per minute generating units not merely of 35,000 kw. but of 50,000 kw. capacity are in successful service and 75,000-kw. units of this speed can be built.

New Castle Station was placed in operation on June 29 of last year by the Pennsylvania Power Co. It is designed on the unit basis with a single steam generator serving a 35,000-kw. generator. It is one of five similar units being installed in various plants of the Commonwealth and Southern Corporation, and from this standpoint, it may well be a measure of future progress as well as past progress. Thus far, very few what might be called standard plants have been built and while the five units mentioned do not necessarily indicate a trend, still the fact that it was found desirable to build them all alike is interesting.

POWER FOR YOUR DOLLAR

Improvements in power equipment and plant operating methods during the past decade have reduced the unit costs of power plant services to the lowest in history in spite of rising prices of most raw materials and construction work. Industry has learned to use scientific information to the economic advantage of all who employ power.

By RALPH E. TURNER
EDITOR, POWER PLANT ENGINEERING

THROUGH NEARLY the entire decade since 1929, stringent economy has been forced upon almost all industrial concerns and as a result much has been learned by those who generate power and those who manufacture power equipment as well as those who use power in its various forms. That advances in power plant practice could take place during these past ten years seems incredible but a retrospective glance and an analysis of conditions will reveal some decidedly beneficial changes that have come about in the industry as a direct result of depression conditions.

It is perfectly true that the fundamentals of power generation have gone through almost no changes in the past ten years. Steam pressures and temperatures as high as we have them today were being used in 1930. The regenerative and reheat cycles were in practical use, as was also the steam-mercury vapor cycle. Although under-water and high-pressure combustion systems have been developed and used experimentally, no new combustion methods are being used practically in power plants; every fundamental type of stoker, pulverized fuel burner, oil and gas burner now available, except for variations in details could have been secured in 1930. Steam turbines as large as any we have today had been installed before the period under consideration. Internal combustion engines have changed only in details. The same could be said about condensers, feedwater heaters, economizers, air heaters, fans, pumps, motors and generators. In the electrical field, a few principles that had been known to scientists have found practical application in power plants within the past few years. In general, the advanced power plant of 1930 incorporated in its design substantially the same fundamental features as are being used in power plants of the 1940 variety.

Definite progress, nevertheless, has been made in the power plant field through the depression years in several directions that has made possible higher thermal efficiencies in plants using equipment of standard design, resulting in lower service costs.

Immediate financial returns are so attractive at times that industrial leaders are inclined to bend their efforts in that direction and neglect to lay the foundations for developments that are in the offing, then find themselves fighting for existence when their products have become outmoded. This was a condition quite general at the close of the boom period of the '20's. Scientists, research engineers and a few pioneering type of power companies had proved to their satisfaction that high pressures and temperatures for steam had practical possibilities little realized by the industry generally. To employ these conditions, however, it was necessary to have not only the principal units in the plant individually designed and specially built for the job but special consideration had to be given to every piece of auxiliary equipment or device used in the plant. Thus it was that the high initial expense placed upon the plant owner who dared to employ scientifically proven methods in advance of general practice acted as a retardent of progress. With manufacturers too busy making established lines to consider developing entirely new equipment for unusual and, perhaps, experimental power plants, the expense of developing suitable equipment was thrown upon the plant owner.

In the early 1930's, however, nearly every manufacturer of power plant equipment recognized the need of bringing his products up to the last word in modern practice which meant, of course, adapting it to temperature and pressure ranges considerably beyond the general practice of the day, requiring not only new materials but in many cases new principles of operation. High furnace temperatures gave refractory troubles that forced improvements in the design of water walls. Boiler design has gone through complete revision as regards arrangement of tubes, the materials of which they are made, the baffling, circulation and many details of construction. Piping, fittings and valves have been completely redesigned. All kinds of regulating equipment has been redesigned making it applicable to a wider range of service, more accurate and reliable in use, and more completely automatic.

With the development of main and auxiliary equipment carried on at the expense of the manufacturer, the plant owner has been offered standard equipment that is suitable for use in the most modern plants at a cost that is extremely low compared with specially designed equipment.

With no other class of power plant equipment has the development been more marked and rapid than it

has been with instruments. Modern power plant operation may appropriately be compared with blind flying for it is only by means of instruments that the most important conditions in the plant can be known and controlled. Impetus was given to the development of many of the present day instruments by the needs of power plants that were advancing their pressures and temperatures and were arranging their equipment for centralized and automatic control. Here again the past decade will be recognized as a period when great progress has been made in the application of well known scientific principles to practical use in maintaining and recording operation conditions. Modern operating instruments are almost of the precision type as regards accuracy, they are more rugged in design, their location is not so limited, extended use is made of electricity and electronics, they are more decorative in design, and their application to new conditions has been rapidly extending.

In the construction of power plants and their equipment, nearly every metal known to industry is used, even some of the so-called precious metals are used for specific purposes. Ferrous metals, of course, are of greatest importance but it has been only in recent years that the art of making ferrous alloys has reached the point where control of quality in several desired directions has made alloy steels available in commercial quantities at economical prices. Progress toward the use of higher pressures and temperatures of steam in the power cycle was definitely delayed until suitable metals could be found that could be used in the design of boilers, piping and turbines to be employed in the new extreme cycles.

In this field also, the past decade has been a period of rapid advancement which has been greatly welcomed by the power plant industry. Research and tests have placed in the hands of designers information on every known quality of industrial metals and alloys, making it possible to select a suitable metal once the

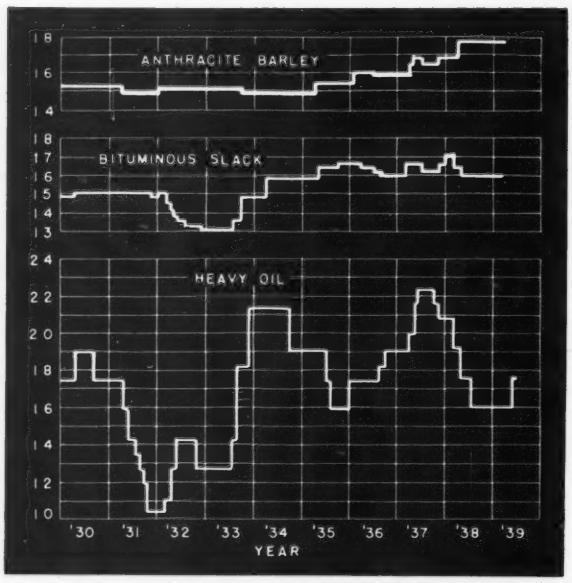


Fig. 1. Variation of fuel prices in cents per million B.t.u. delivered by barge at New York harbor water front. From paper by Gasta A. Anbro before the A.S.M.E.

requirements are known. Scientific use in steels of such materials as chromium, nickel, manganese, silicon and carbon permits the metallurgist to vary to a considerable degree the various qualities of the metal; such, for example, as melting range, magnetic permeability, thermal conductivity, coefficient of thermal expansion, tensile strength, yield point and hardness—all of which need to be definitely known by the designer of power plant equipment before the metal can safely be used. This contribution of science has a value that can scarcely be estimated.

Developments in other materials have also been instrumental in permitting power engineers to come nearer to the theoretical conversion of heat into power. Among the most outstanding of these are refractories, building materials, ceramics, heat and electrical insulating materials, heat conveying liquids, luminous vapors, fuels from industrial waste materials, lubricants and plastics.

Closely related to the developments in materials, in fact making these developments possible, are methods now available, and growing more popular in use, for fabricating and binding materials together. Fusion welding, for example, has completely revolutionized

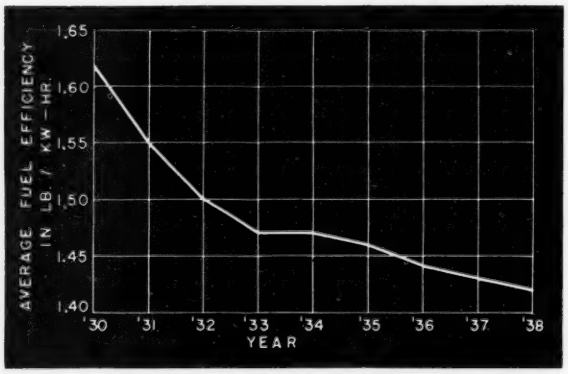


Fig. 2. The engineer's answer to rising fuel costs is higher efficiency of operation. This curve shows the average fuel consumption in utility, light and power plants in the United States

the metal manufacturing industry, permitting a choice of metals previously impossible; forging of parts is now taking the place of casting in many instances, with beneficial results; welding and soldering are displacing screwed and flanged pipe joints to a large degree; cementing and sealing methods have undergone radical changes in recent years; surface welding and hardening have distinct fields of usefulness in manufacture and repair work. Along with these processes has come the extended use of the X-ray, electric furnaces and electric annealing devices.

Having proved by pioneering power plants that the high-pressure, high-temperature steam cycle was considerably more efficient in actual operation than former commercially applied cycles, many power companies found themselves with comparatively new plants that were rapidly becoming obsolete because they were not equipped to employ the new steam conditions then becoming economically advantageous. This situation was met by superposing upon the existing plant steam and electric generating equipment designed for the upper temperature and pressure conditions and

exhausting at the proper pressure into the steam supply line to the existing turbine. This method of extending plant capacity presented a number of fundamental advantages but the economic advantage of building such extensions was for a time delayed because of the expense of having specially designed equipment and auxiliaries developed for this service. When, however, manufacturers recognized the growing demands and set about to develop standard equipment for the new service, thus reducing the cost consider-

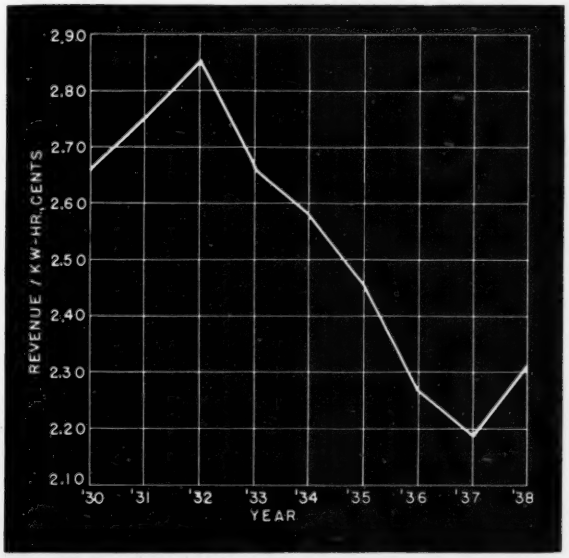


Fig. 3. Commercial consumers of electric power are reaping the benefits of higher efficiencies by reduced revenues per kw-hr. to utilities

ably, many superposed, or topping plants as they are commonly called, have been built and put into operation.

One of the most troublesome operating problems encountered in any steam generating plant is the treatment of the boiler water to prevent the formation of scale, the corrosion and embrittlement of boiler metal and the carryover of solids that form scale on the turbine blades. These problems were all perplexing enough when pressures as low as 200 lb. were considered high but with each additional boost in pressure new and more perplexing and dangerous conditions presented themselves. To meet these, chemists have devised a number of water treating methods that are giving excellent results but in all cases continuous and careful attention to boiler and water conditions is required on the part of the operating staff. Much of this boiler water research has been carried on during the past decade.

Although the large and unusually designed plants have attracted the most attention, probably the greatest advancements or the most important ones have taken place in the design and operation of the smaller plants serving industrial establishments. Reflecting the pioneering that has been done by the leading large power plants, industries requiring replacement of their worn out equipment or extension of their power plant services have examined and in many cases are using pressures and temperatures comparable to those

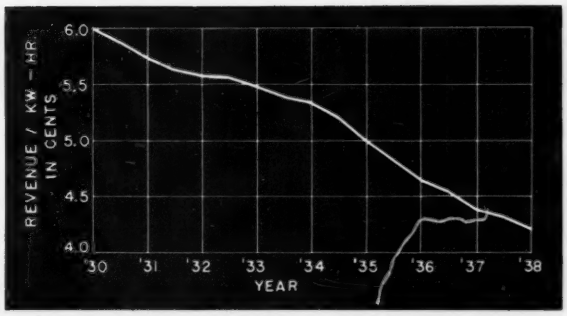


Fig. 4. The average revenue per kw-hr. from residential consumers of electric power has shown a steady decrease

in utility plants, but in addition many of these plants are finding that new cycles especially adapted to their particular problems can be employed to their economic advantage. In fact the variety of uses for steam bled or exhausted from turbines in industrial plants is considerably greater than in plants devoted strictly to power generation. To these plants have come, with very little expense for development, manufactured equipment, much of it in standard form, which has taken years to develop but is now so perfected that guarantees of performance in service are made by the manufacturers.

As to the small plant, many of the methods and much of the equipment employed in large plants have been readjusted and designed for lower capacities with the result that much higher efficiencies now prevail in these small size but numerous plants. Fuel burning equipment of the automatic type is now within the economical reach of every steam generating plant even down to the household size; the Diesel engine has made power generation economically possible in plants where little or no need for heat exists, even in many cases competing with available utility service; decided improvements have been made in power plant instruments making it possible to secure higher efficiencies in operation and more authentic cost records; highly effective water treating methods now employed have played a very important part in advancing boiler efficiency in the small plant.

Inventive scientists have seen visions far ahead of the industrial research technician whose work demonstrates what can be done and establishes limits of practical applications of principles and materials. It is upon these workers in fundamental sciences that the engineer must depend for information on materials and processes in order that he may improve industrial methods of supplying people with their material needs. A continuous flow of new ideas worked into industrial applications is as important to the welfare of the country as daily food is to an individual. No manufacturer can expect to remain long in business who does not continuously improve his product. Likewise power plants rapidly become obsolete if they are not continuously being brought up to date by the employment of new devices or auxiliaries or even new main units and methods that improve the economy of power generation or other services of the plant. To delay in making these advancements is to suffer starvation with the danger of extinction in the field of competition.

PROGRESS IN THE DEVEL

Making power economically by the employment of new processes is an art that has been highly developed during a period of business depression. The modern high-pressure, high-temperature, high-efficiency plant does not require extraordinary skill nor advanced scientific knowledge on the part of the operator.

By R. C. ROE
BURNS & ROE, INC.
Consulting Engineers, New York, N. Y.

IN THE period of the last ten years the world has been going through a time of great economic stress. The result has been that while there has been little development in the form of new power plants and new construction until the latter part of the ten year period, there has been great development in the form of new processes and advance in the art of making power economically. In other words, we have had a period of less activity which permitted many men to turn their thoughts to improvement and better methods rather than the construction of new plants.

The result of this mass thinking on power generation has been very marked as demonstrated by the very different type of power plants and power generating equipment now being installed as compared with the best that was available ten years ago.

Most power engineers, both industrial and central station, and most users do well to give consideration to the new developments, many of which have a direct bearing on operating costs.

The trend in the last ten years has been more and more toward higher pressures and higher temperatures. Ten years ago there were a few, in fact very few, plants in this country operating at 1200 lb. or more. Now there are many plants of this pressure or higher, both utility and industrial, in fact 1200 lb. has become quite usual for large high-efficiency units. The maximum commercial temperature was formerly about 750 deg. F., today a number of plants are in operation, and more are being built, for 900 deg. or even up to 950 deg. F.

In every steam power plant only part of the energy in the steam is available to produce power, the remainder is either rejected to the condenser and therefore lost, in the event of atmospheric exhaust, to the air or to various process uses in some industrial plants.

In general, for any given exhaust condition the higher the initial pressure and temperature, the greater the portion of the heat energy available for power production is compared with the total heat in the steam or in other words, the higher the pressure and temperature, the less the total heat loss is to the condenser or to the atmosphere.

Figure 1 shows this tendency clearly as it is based on the heat available at the pressures and temperatures noted for the production of power if the prime movers were 100 per cent efficient and could use all the available energy between the initial conditions and 1 in. Hg.

In cases of process work, the higher the initial pressure and temperature, the more power can be made per pound of steam used as process steam.

In this phase of the improvements in power cycles, the effect of increased temperature is more marked than the effect of increased pressure. To obtain the best result, these two, i.e. pressure and temperature, should in general go hand in hand as they are increased or decreased.

The use of high pressure requires boilers, piping and turbines designed and built for such pressures, together with pumps and auxiliary appartus designed to function with the higher pressure boilers and turbines.

The use of high temperature usually requires the use of alloy steel in the parts exposed to temperatures above 800 to 850 deg. F.

In a great many cases, however, the cost of the heavier equipment and of the alloy steels is indeed well justified by the saving in operating cost resulting from the use of high pressure and high temperature.

Regenerative Cycle

Another method of improving the ratio of heat energy available for the production of power to that lost in the exhaust is by means of the regenerative cycle.

The regenerative cycle is not new in itself but is coming more and more into extensive use and is being greatly improved in recent years.

Briefly, the regenerative cycle is a means of successively increasing the temperature of the feedwater by exchanging to the feedwater heat from steam bled or extracted from the turbine at a number of points along the steam path of the turbine, each successive point being of higher pressure and temperature than the preceding one.

L OPMENT OF HEAT CYCLES

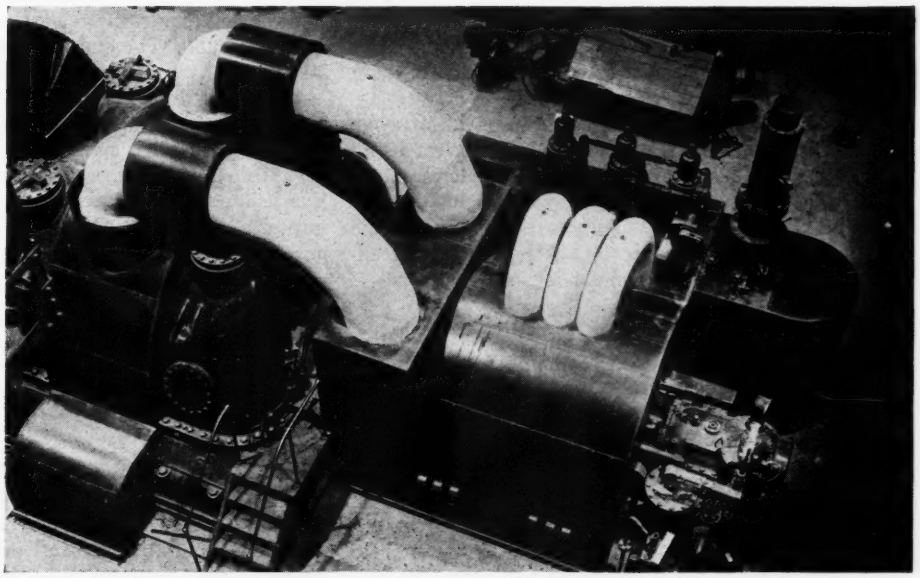


Figure 2 is a diagram of a multiple point regenerative cycle in use in a moderate size central station. It can be easily seen that as the feedwater passes from the condenser through the various heaters to the boiler that its temperature is successively raised by the heat of the steam extracted from the turbine to the various heaters and condensed therein.

Inasmuch as the latent heat of the steam condensed in the feedwater heater is absorbed by the feedwater and carried back to the boiler and therefore is not rejected to the condenser, and inasmuch as the steam to the heaters has done some work in the turbine and given up some of its heat energy in the form of power, it is evident that the ratio of heat energy available for the production of power to that rejected to the condenser has been improved, hence the cost of power decreased.

There are two general methods of transfering heat from steam to feedwater; one by means of transfering the heat through metal tubes in what is known as closed heaters, and second by means of mixing the steam and water together in a single vessel in what is known as open heaters or more properly the direct contact heater.

Direct contact heaters are probably one of the oldest means of heating feedwater but have been little used for multiple point regenerative feedwater heating until about eight to ten years ago when a new system of regenerative direct contact heating was developed which has proven very successful and is gradually coming into more extensive use.

Both the closed and the direct contact types of regenerative feedwater heating are being commonly employed today with good success and although the direct contact system is in general more efficient, the gain in economy of either is such that it is desirable to give serious consideration to the best possible regenerative cycle when planning new steam power equipment.

In the closed system of regenerative feedwater heaters, the steam being condensed in each feedwater heater is kept separate from the feedwater by means of the metal tubes separating the steam from the water. The condensate from the condensed steam in the feedwater heater has to be removed from the heater and should be returned to the boiler. This is usually done by permitting the condensate to flow to the heater of the next lower pressure controlled by a trap or drainer and then from that heater to the next lower and so on until it is finally picked up by the condensate pump or the boiler feed pumps and returned to the boiler. This method is generally known as cascading of the drips. There are a number of other methods of caring for the condensate such as using special pumps known as drip pumps on each heater or on small groups of heaters which take the condensate and pump it back to the boiler either directly or through the boiler feed pump.

Still another method and one which is finding great favor recently is the drip cooler which is a submerged heat exchanger (see Fig. 2) exchanging a portion of the heat from the leaving condensate to the entering feedwater to the heater.

In all closed heaters there is a resistance to the flow of heat from the steam to the feedwater caused by the film on both sides of the metal tubes and the resistance of the tube metal itself, with the result that the water never leaves a closed heater quite as hot as the steam within the heater.

The cascading of drips or condensate also decrease the efficiency of a closed heater cycle to some extent because it decreases the amount of steam that can be extracted from the lower pressure bleed points by about the amount of heat in the cascaded condensate.

In the direct contact regenerative heater system the steam mixes with the feedwater. There is little resistance to heat transfer and therefore the water leaves the heater at the temperature of the steam unless there is superheat in the steam. Each heater picks up its own condensate and hence there are no cascading losses.

Special pumps and control systems are required to handle the water between heaters and somewhat more extensive piping is usually required.

Figure 3 shows a mass flow diagram of a heat cycle of a modern central station in the Middle West using a direct contact heater system on the four lower bleed points and closed heater with drip cooler on the two upper bleed points. This mass flow diagram is to scale and therefore the large gain by the regenerative feedwater cycle can be easily visualized.

Binary Fluid Cycles

The present indications are that the binary fluid cycles employing mercury again will be a factor in the production of low cost power, although the advent of higher steam pressures and temperatures with the resultant gains in steam cycle efficiency have to some extent decreased the margin in favor of the mercury steam cycle but notwithstanding this fact there is still available a substantial margin in favor of the mercury steam cycle in many applications and when the operating difficulties have been corrected we may expect this cycle again to come to the forefront.

The binary cycles, that is cycles using two fluids such as mercury and water, have not made much progress in the last few years largely because it was necessary to correct unexpected operating difficulties with the mercury end of the mercury vapor cycle.

Several stations were built some years ago employing not one superheating of the initial steam but also re-superheating of the steam after it had been partially used in the turbine.

The resuperheating added some complication to the steam cycle although it did improve the efficiency greatly. With the advent of higher temperatures reheating has not been so popular as the tendency was strongly toward simplification. The advent of higher

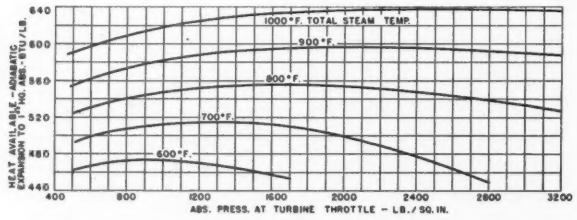


Fig. 1. Heat available from steam when expanded adiabatically

temperatures, however, does not make obsolete the resuperheating cycle, in fact if the higher temperature is accompanied by higher pressure, resuperheating becomes all the more valuable and therefore we may look forward to seeing the reheat cycle or its equal return to favor in high-pressure, high-efficiency stations.

Figure 4 shows the heat rate of a condensing station based on a good regenerative cycle with hydrogen cooling for the generator and 1 in. Hg. back pressure for various initial pressures and temperatures with and without reheat. It should be noted in Fig. 4 that the results shown therein can be produced in a well engineered plant containing modern equipment of moderate size. In some cases slightly better results than those shown could be produced and in other cases slightly poorer results. The curve should be taken to represent about the average in the present state of the art of a very well designed station. The effect of reheat is clearly shown on these curves and the results indicated are better in some cases than has heretofore been accomplished in commercial stations now operating in this country but nevertheless are results that can be produced today. No operating tolerance is incorporated in these curves.

Sound Engineering Essential

While we have set forth some of the gains in the art of power production in the last ten years perhaps a word of caution is also desirable.

Like all lines of human endeavor high pressure, high temperature are not always applicable for the best results, and reheat should not always be used. The regenerative feedwater cycle has its place but is not a cure-all and therefore all or any of these very important and very valuable improvements should be used only when their application has been carefully worked out and carefully engineered to the end that the maximum results may be obtained.

Operating engineers who are interested in continuous service and owners who are interested in return on their investment are naturally wondering what added attention and what difficulties are likely to be encountered in the use of equipment such as discussed in this article for the more economic production of power. This phase of the matter has a direct bearing on the desirability of installing such equipment and on the amount of net earnings which would accrue as the result of such installations. Therefore it is well to give consideration to this very important phase of the matter.

The first requisite for any power station of either high or low pressure is sound engineering, both by the manufacturers on the one hand and by the engineers responsible for the installation on the other hand, in order that the equipment may be properly constructed and properly coordinated to the user's needs.

Equipment that has been in use for a great many years naturally has by repitition been seasoned to a point where it can be installed as a routine matter without much effort in the form of engineering, except that required by the installation itself. In the power plant field such equipment is usually obsolete before it is installed because the power production art has advanced too rapidly to permit this type of seasoning on any modern equipment. Therefore the first fundamental of successful installations of modern and efficient power plant equipment is sound and careful engineering, both in its manufacture and its application.

As the pressure of boilers increase, the density of steam more nearly approaches the density of water.

This tendency has a decided effect on both boiler design and operation.

From a design viewpoint, it is necessary to recognize that the hydraulic heads of the boilers are adversely affected by the decreased density relations between the water and the steam as the pressure increases, and therefore hydraulic heads are lowered unless the percentage of steam to water is increased. Inasmuch as it is unsafe to increase this percentage indefinitely, it follows that the hydraulic circuit in the boiler must be more liberally designed and more carefully worked out. This is particularly true in those parts of the boiler adjacent to the fire where high heat absorptions take place. Also the fact that the density of the steam is more nearly approaching that of the water indicates the necessity of better separating equipment not only to separate the water from the steam, but also to separate the steam from the water in the downcoming hydraulic paths of the boiler.

continuous and scrupulous control and treatment of the water within and without the boiler.

Reliability a Function of Operation

Modern boilers, either high or low pressure, are inherently reliable provided they are properly operated. The improvements in furnace design, the tendency toward water cooled furnaces throughout, the better control of the distribution of the gases and the fly ash over the boiler surfaces and the better control of the slagging problem all have a tendency to make the boiler more reliable than the boilers designed a few years ago provided a few simple precautions are taken, both as to water and as to fuel in its relation to the particular furnace design procured and as to methods of burning fuel within the furnace.

The question of pumping the boiler feedwater to the boiler in high-pressure boilers is probably the third item which is fundamental in its importance.

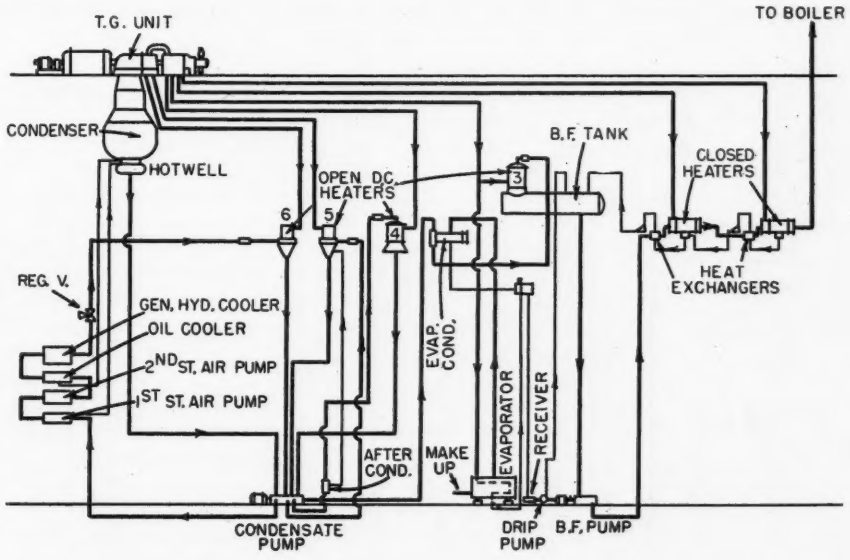


Fig. 2. Schematic diagram of equipment and connections for a regenerative cycle

Assuming proper design attention to both hydraulic circuits and steam and water separations, or steam purification, then it is necessary for the operators to recognize the fundamental difference between high and low-pressure boiler operation because high-pressure boilers are inherently more sensitive to water conditions than are low-pressure boilers. Therefore boiler concentrations should be kept low. A continuous and scrupulous control should be exercised over the water supply to the boiler and entrained gases must be eliminated. The word "eliminated" used in this connection should be emphasized because actually it means total elimination or to all practical purposes total elimination. Chemicals should be supplied to the boiler as may be necessary to obtain proper pH values and alkalinities but internal treatment should not be used as a cure-all for poor water. Rather the water should be good before it enters the boiler and the treatment should be of a supplementary and protective nature and as little as possible of a corrective nature. Therefore, the second fundamental of successful operation at high pressures is good water and

As pressures increase, the difficulty of pumping also increases, particularly if the quantities are small and if centrifugal pumps are used. Most high-pressure boiler-feed pumps, because of the desirability of efficient heat cycles, operate at fairly high temperatures and because of the high heads involved operate at fairly high speeds, usually around 3500 r.p.m. The pumps should be designed so that stuffing boxes are not subject to high pressure or temperature and when pumping hot water the positive head on the suction side should be increased materially over that which has heretofore been the practice. Packing boxes should be large and well designed even though it means increasing the length of the span between bearings. The pumps should be mounted on their horizontal center lines so that they can expand both ways from that center line and not in one direction from the base. Arrangements should be made so that when the rotating equipment mounted on the shaft expands it will not distort or otherwise stress the shaft.

Having selected a well designed centrifugal pump for high-pressure boiler-feed service, there are some

operating factors which need consideration. The pumps operating at high temperature should not be subject to severe and quick temperature stresses, otherwise distortion in the case or shaft is likely to take place. If leak offs are provided, they should be taken back to the heater or tank from which the pump takes its suction and not directly to the suction of the pump itself. In other words, by taking the leak offs back to the tank or heater, there is time and space provided for the separation of steam and water and therefore the pump is not compelled to repump vapors made by its own losses.

Under light loads, means should be provided to recirculate a portion of the pump discharge through a controlled orifice to the heater or tank from which the pump takes its suction. Otherwise in some cases under light load operation the internal losses of the pump itself may be great enough to cause the pump to steam bind under light load conditions.

When a pump is shut down and not operating but is expected to be ready to operate, it should be kept at uniform temperature throughout. There is a difference of opinion as to how this can best be done. Some people, including the author of this article, prefer to allow the pump to reach and maintain room temperature throughout under which conditions there would be no distortion. Others prefer to try to keep the temperature of the pump up to approximately operating temperature by artificial circulation of heated water through the pump. The fundamental requirement is that the pump be of uniform temperature and not that one part of the pump be hot and some other part cold which obviously would cause distortion and possible difficulty.

Packings should be carefully designed, not installed too tightly against the shaft to cause undue friction nor too loosely which might cause blow outs. It is necessary to watch packing a little more closely on high-pressure pumps than on low-pressure as the results of improper attention to packing are more serious.

High-pressure boiler-feed pumps are in the present state of the art a reliable piece of equipment, provided they are well chosen and the comparatively simple precautions pertaining to operation are followed. Therefore, the third fundamental in successful high-pressure plant operation is careful choice of the boiler-feed pumps and careful operation of this vital equipment after it has been chosen.

In considering high temperatures as distinguished from high pressures we are immediately faced, if the temperature is over 825 deg. and in some cases with temperatures slightly below this, with the necessity of using alloys for high-temperature piping and fittings, boiler and turbine parts. Some trouble has been experienced in the past due to lack of knowledge of the effect of temperature on metals. This type of trouble will probably repeat itself in the future as attempts are made to boost the temperature ranges higher and higher. Up to 900 deg. or thereabouts, or even perhaps slightly higher, there is today little need for troubles resulting from lack of knowledge of the effect of temperature on metals and there is every reason to believe that with careful design high temperature installations are safe and reliable.

Insofar as the boiler is concerned, as the temperature of the steam increases the amount of heat transfer surface used for superheaters and reheaters increases. In some of the most modern installations this surface has reached a point where difficulties in proportioning the heat absorbing surfaces of the boilers have been experienced because the heat absorbed by the superheaters and reheaters is such a large proportion of the total heat absorbed by the boiler that it is difficult to position the surface and yet have much if any protection from the radiant heat of the furnace.

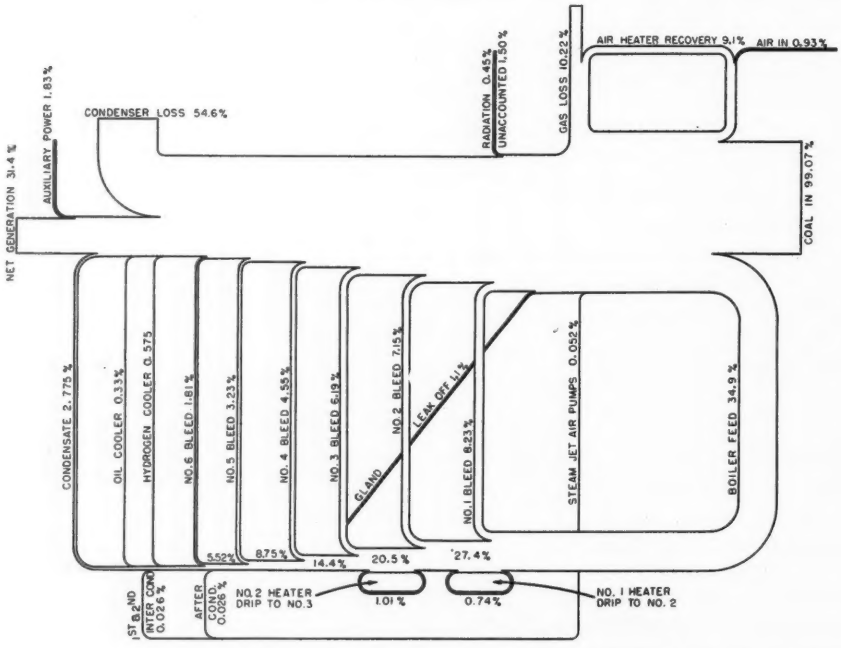


Fig. 3. Mass Heat Flow Diagram. Drawn to scale with the heat in the incoming air for combustion and the fuel representing 100 per cent. The heat in the net generation represents 31.4 per cent and the losses are as set forth in the diagram, the condenser loss being 54.6. This represents a particularly good regenerative cycle using partly direct contact heaters and partly closed and the heat picked up by each heater is shown both by percentage and by the scale of the drawing. The total heat returned to the boiler by the feedwater largely as a result of the regenerative cycle equals 34.9 per cent of the heat supplied to the boiler in the form of fuel and air. It is easily seen that if this large recovery were not a part of the cycle the cost of fuel would be greatly increased

In general, high-temperature superheaters have to work closer to the safe working temperature of the metal. Therefore, from an operating viewpoint it is essential that care be exercised in starting the boiler to insure that the heat input during the starting period will not overheat the metal in the superheater beyond safe working temperature. Also the distortion of gas flow throughout the superheater due to slag accumulations should be carefully avoided to prevent overheating of some sections of the superheater due to unreasonable concentrations of heat resulting from distorted gas flow.

Piping structures for high-pressure, high-temperature work are nearly always welded and valves in most cases welded in the line. Valve seats are nearly always stellited and in some cases even valve bonnets have been welded in place. This whole change in practice, assuming that the piping system has been properly designed, properly preheated and properly stress relieved, results in pipe lines which are better than the flanged pipe lines which have been in vogue before. Therefore, pipe line troubles should in general decrease over the heretofore expected standard.

Turbine Operation

Turbines operating at high temperatures should be brought to speed and to temperature slowly. There is undoubtedly less stress on a turbine throttle at all loads. In large size units there has been some difficulty due to the combination of high temperature with tremendous energy conversions in the first wheels of certain types of turbines. This difficulty should not be feared in units of moderate and small sizes and it is believed that the manufacturers have this matter well in hand even in large sizes.

Given proper materials and a few simple operating precautions, there is no fundamental reason why the reliability of high-temperature boilers, piping or turbines should be less than was the previous lower temperature equipment.

In general, the requirements for high-temperature operation are a recognition of the fact that temperatures should be changed slowly, that metals should not be heated beyond their safe working temperature and should not be stressed or distorted by violent temperature changes, and that the working stress should be reduced in all metal parts subject to elevated temperatures compared with the stresses that would be permissible at lower temperatures. Recognizing these fundamental facts, no operating difficulties of any magnitude should be encountered.

The regenerative cycle is one of the most prolific means of improving plant economies. Although the gains in the regenerative cycle are greater at high pressures than at low, the gains are substantial on properly designed regenerative cycle installations at any commercial pressures. With the closed heater regenerative cycle, the heaters should not be subject to intensive temperature shock but rather should be arranged so that the temperature can be changed gradually. Drainers and traps for closed heaters require periodic attention to be sure that they are in working condition and not inoperative or stuck. Drip pumps for closed heaters should not be used in small

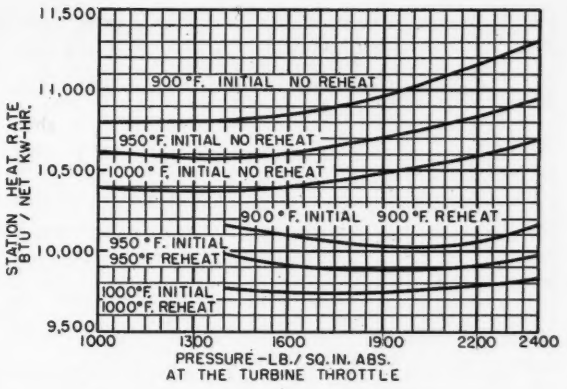


Fig. 4. Station performance based on six stage regenerative cycles, hydrogen cooling and one inch mercury absolute back pressure

sizes but may be desirable in large size installations. Direct contact heater systems not having tubes in the heaters are not susceptible to as much damage from temperature shocks as are closed heaters. A direct contact heater system, however, must be carefully engineered as a complete system in order to be fully successful. Inasmuch as the success of the direct contact heater system depends almost entirely on the soundness of its engineering and the ability of its pumping and control apparatus to coordinate the flows of water in proportion to steam flows, it is essential that the design of these systems be placed in the hands of those few manufacturers who by experience and knowledge are qualified to do this work. Given proper design, direct contact heater systems are not difficult to operate and by most users are considered to be a trouble free type of apparatus.

In general, whether the system used for the regenerative cycle is a closed system with or without drip coolers or a direct contact system, there is no reason to anticipate any great difficulty in operation and the operating engineers or users should not be averse to taking advantage of the large economies which are possible through the regenerative heater systems.

In conclusion, let us say that there is nothing in high-pressure, high-temperature, high-efficiency plant operation which cannot be met by careful and intelligent operators who are interested in their job. The modern plant does not require extraordinary skill or extraordinary knowledge to properly operate it. It does require somewhat better maintenance, the exercise of a few simple precautions, the type of operator who either has operating knowledge of modern equipment or who is willing to learn, who is interested in his job and who will take pride in his plant. Experience has shown that good operators who are capable of operating less modern equipment after short periods of experience and training make good operators for the newer equipment. Inherently the modern high-pressure high-temperature equipment is not less reliable but more reliable than the less modern equipment preceding it. The gains from high temperatures, high pressures and high efficiencies are therefore available to all power users where equipment of this type fits the use and will effect economies.

THE DEVELOPMENT

Metallurgists undertook the task, placed before them by industry ten years ago, of developing metals that could be used with safety and economy in high-pressure, high-temperature steam plants. The principal advancements in this direction are related this review of technical progress in metals.

THE GOAL of the power industries to utilize the greater efficiencies possible through high operating temperatures and pressures in steam power plants, has challenged the ingenuity of the metallurgist during the past decade. A recapitulation of the benefits which the steam plant has derived through the development of new metals and metallurgical technique since 1930, would show that operating temperatures and pressures quite common today, were then considered well beyond the practical capacity of the materials then available.

In 1931 a symposium on the properties of metals at elevated temperatures before the A.S.T.M., set forth in a paper by H. J. Kerr, the balance between what industry could ask for and that which the metallurgist could produce. It was made quite clear that the power industry contemplated the improvement of its efficiency by either increase in pressure of the steam, or by increase in temperature of the steam. Either or both of such changes in practice called for new materials of greater potency to be made commercially available, for the then prevalent materials and methods of application were being pressed to just about the limit to which engineers dared go.

In 1930 the top pressures in common use were around 600 lb. per sq. in., and few plants carried temperatures beyond 750 deg. F. Today 1500 lb. per sq. in. units and steam temperatures of 925 deg. F. are becoming quite common, with a number of other units either contemplated or realized for even higher pressures and temperatures. Such has definitely been accomplished through the development and application of new materials unheard of in 1930.

Of late years, more emphasis seems to have been laid upon materials to stand higher operating pressures than upon advancing operating temperatures. Temperatures advanced in a decade from 750 deg. F. to 950

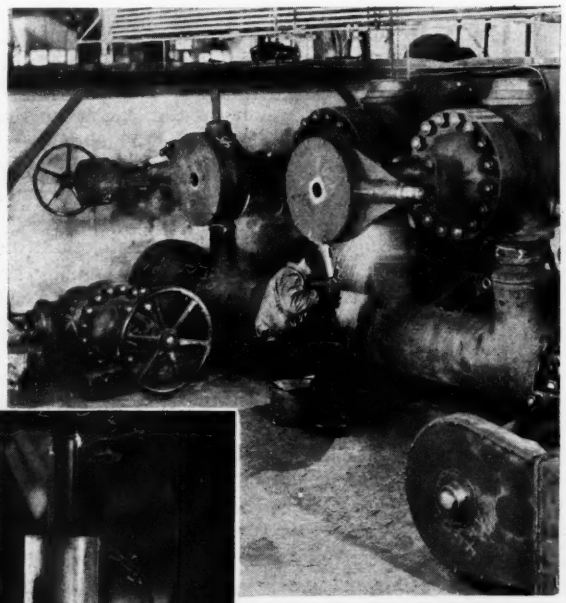


Fig. 1. (Left) Measurement of the Creep of Metals

Fig. 2. (Above) Welding Valves to 1500 lb. Main Steam Headers

OF METALS

By J. J. KANTER
Research Metallurgist, Crane Company,
Chicago, Illinois

deg. F., principally through the introduction of new high strength steels adaptable to fabrication and installation by welding processes. This has been accomplished economically, and in many instances at savings over the older equipment limited to lower temperatures. Careful researches upon the high-temperature properties of steels, have indicated that to press temperatures much beyond the present limit would increase the investment in materials to figures not warranted by the return in increased efficiency to be anticipated from that source. Pressures, however, continue to

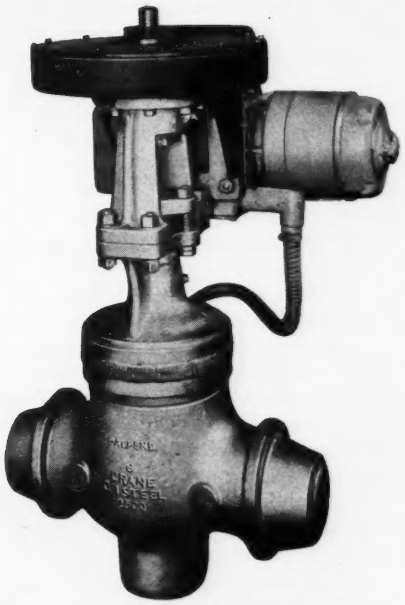


Fig. 4. All Welded Flangeless 2500 lb. Cast Steel Valve

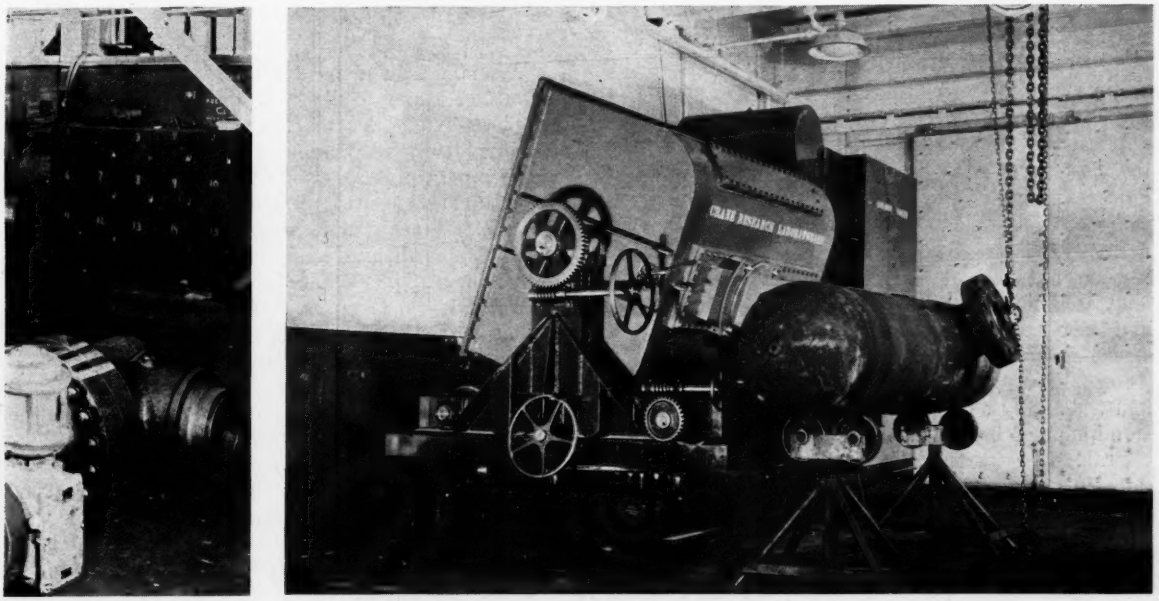


Fig. 3. Radiographic Examination of Pressure Vessels

increase, not so much because of any considerable gain in thermo dynamic efficiency, but because of the reduced size and increased capacity of units to be attained. By increasing pressures, a greater return is obtained on the equipment itself, rather than the basic fuel.

Welded construction in the power piping field has been by far the greatest individual factor in the change of practice during recent years. However, before welding could be applied on the scale it is now used, steels of weldable specifications had to be developed which would have adequate high-temperature strength of "creep resistance". Much has been learned in recent years about the requirements of steel to have superior strength at temperatures up to 950 deg. F. It does not necessarily have to be an alloy steel. Much has been done to improve ordinary carbon steel for such service, by specifying the "killing" practice to be used in the steel making process. Whether a steel be "silicon killed" or "rimmed" has been found to exert a profound influence over its creep resisting qualities and this fact is now given considerable cognizance in A.S.T.M., A.S.M.E., and other materials specifications for pipe and fittings for high-temperature and high-pressure service.

At the present time the A.S.T.M. has adopted no

less than nine specifications pertaining to pipe and tubing for high-temperature application. Indeed the activity of A.S.T.M. in the field has brought about the organization of a number of special and very active committees to follow the developments in the field of high temperature pressure application of materials, and to formulate specifications covering not only piping, but also castings, forgings and bolting for these specific purposes.

In the defining of weldable grades of steel, much research has been expended. It has been deemed necessary to carefully limit the carbon contents of all grades entering welded fabrication. To insure that welds will have the proper ductibility, soundness, and integrity, exacting techniques of welding, heat treatment, testing and inspection have become accepted practice. Radiographic examination of welds for soundness and insurance against defects has become of great value in developing welding procedure. The qualification of the welder's ability to work on a job has become a matter of definite code requirements by the A.W.S. and A.S.A. Code for Pressure Piping.

A decade ago, when metallurgists were casting about for alloy steels to withstand the increased demands of advancing pressure and temperature, much attention was given to the various recipes for strength and toughness which had been evolved for machinery purposes, particularly the automobile. Whilst these more or less highly alloyed compositions with chromium, nickel, vanadium, tungsten, etc. had great merit for developing strength and toughness in mechanical applications at ordinary temperatures, they were for the most part found lacking in the peculiar set of requirements with which the steam power engineer was confronted. He had to have a material which would not only be strong and tough for high temperature service, but he had to have a material which would lend itself to the critical welding method of fabrication and installation. The automotive alloy steels, while strong at ordinary temperatures, were not necessarily "creep" resistant at high temperatures, and usually had the highly objectionable feature from the welding standpoint of being "air hardenable" to a degree intolerable in a welded joint. Where welding had to be done in installation, and where shop methods of heat treating and "stress relieving" joints could not be applied, a non air hardening material was sought. The need has been admirably filled, simply by the addition of one-half of one per cent of molybdenum to carbon steel. This is the popular and widely used carbon-molybdenum steel currently used for piping, welding fittings, forgings, boiler plates, and castings entering into power plant equipment. Of course, much more than simply the addition of one-half of one per cent of molybdenum is implied in the effective application of carbon-molybdenum steel to elevated temperature operations. Unless the correct heat treated structure of this material is maintained throughout its manufacture, fabrication, and installation, it may not afford any real gain over ordinary carbon steel so far as its high temperature strength is concerned. The tensile strength of carbon-molybdenum steel is only moderately higher than that for carbon steel of equivalent carbon content. The comparative minimum tensile properties between carbon steel pipe and carbon-molybdenum pipe, as specified by A.S.T.M., are as follows:

	Tensile Strength P.s.i.	Yield Point P.s.i.	Elongation in 2 in.
Carbon Steel (A106-36) Grade A	48,000	30,000	35.0
Carbon Molybdenum Steel (A206-38T)	55,000	30,000	30.0

The outstanding quality of carbon molybdenum steel pipe, is its greater creep strength at high operating temperatures. In the A.S.M.E. Power Boiler Code, maximum allowable working stresses have been adopted for ferrous materials based in the lower temperature ranges upon tensile strengths and safety factors, but at the high temperatures upon creep data. Up to 650 deg. F. the carbon steels are permitted to be worked at one-fifth of their minimum specified tensile strength. In the case of carbon-molybdenum steels, one-fifth of the tensile strength is permitted up to 800 deg. F. Above these limits (650 deg. F. and 800 deg. F.) maximum working stresses are based upon 80 per cent of the creep stress, which limits deformation to one per cent per 100,000 hr. Working stress values in lb. per sq. in. abstracted from the Boiler Code table of stresses for pipe, are as follows:

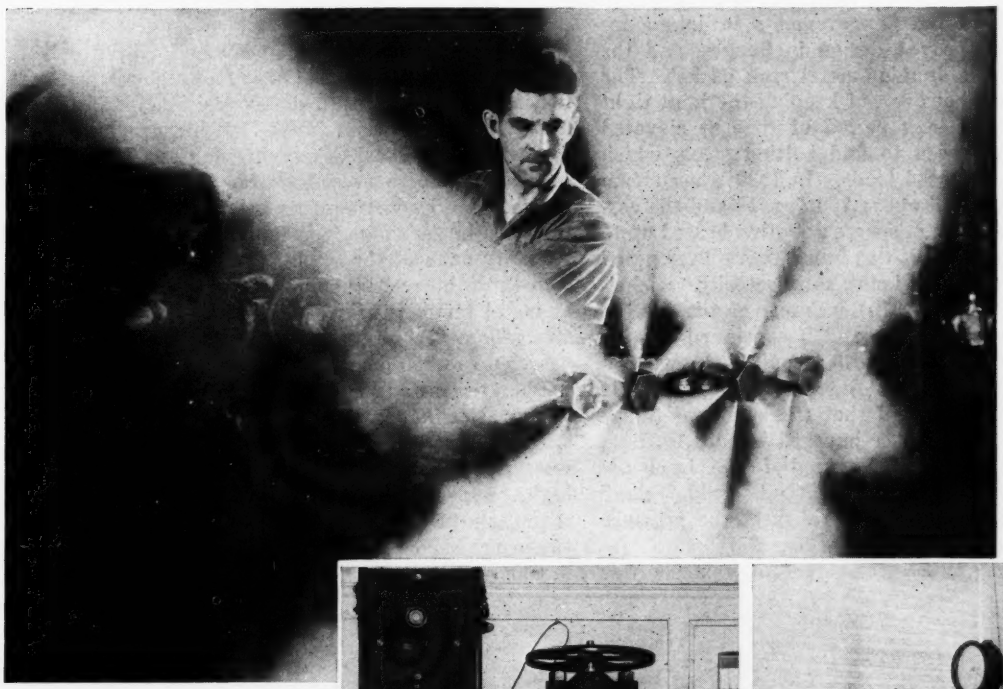
	—10 to 650°F.	750°F.	800°F.	950°F.	1000°F.
Non-killed carbon steel (Grade A)	9400	8100	5850	2600	....
Silicon killed carbon steel (Grade A)	9400	8600	6800	3800	2000
	—10 to 800°F.				
Carbon-molybdenum	11,000	....	10,500	8000	5000

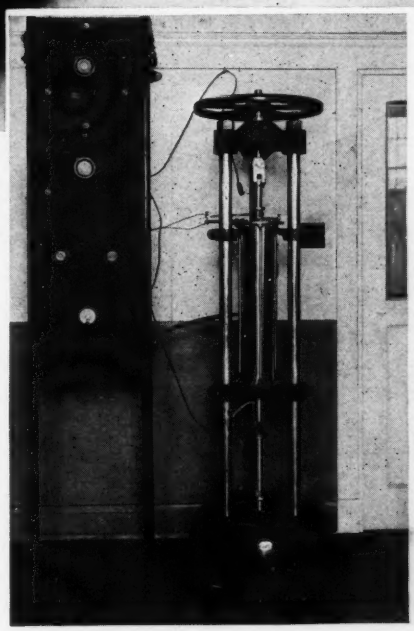
A comparison of the stress values shows at once the advantage which has been gained through the use of carbon molybdenum steel in the design of pipe for operation at temperatures above 750 deg. F. This gain in high temperature, however, depended to a considerable extent upon the control of manufacturing variables and the heat treatment of the steel. Some metallurgists advocate that a definite grain size range, as determined by metallographic examination, must be maintained to insure optimum creep resistance in this steel, and revisions to the A.S.T.M. specifications for pipe incorporating such a requirement has been proposed.

The development of weldable grades of steel suitable for elevated temperature, has led to some rather revolutionary changes in the design of steam piping and fittings. Flanged valves and fittings joined by bolts or studs, are rapidly being displaced in many high temperature and pressure applications by welding-end designs. These designs present a tremendous advantage in tightness and weight savings over the former designs. In the extremely high pressure equipment the weight saving through elimination of all flanges is of the order of 50 per cent. The manufacture of welding end fittings has assumed considerable proportion and the need of suitable material in these lines is being diligently dealt with by the standardization bodies. Wherever steels are needed for the manufacture of articles that require welding, either in fabrication or installation, it has been found that an entirely new set of standards and requirements must be drawn up.

The trend toward welded piping has greatly affected the design of cast-steel pressure vessels. Numerous lines of high-pressure cast-steel valves and fittings with welding ends instead of the cumbersome flanges necessary at high pressures, are now available

for power plant uses. A great weight saving in some high-pressure cast-steel valves has been achieved by welding the bonnet directly to the body. The demand for weldable steel castings has been the subject of considerable study and development in the steel castings industry. In attempting to furnish castings in grades of steel which are readily weldable, the steel foundryman is beset with certain difficulties and limitations, not encountered in the manufacture of wrought steel products. As pointed out previously, ease of weldability has been found to depend to a great extent upon maintenance of low carbon contents in the steel. This rule applies to castings as well as pipe, plate, and forgings. In supplying steel for the wrought products, the steel maker is able to select from his stock, billets of the appropriate chemical composition to meet the weldability requirements. On the other hand, the steel founder must be sure that the steel in his ladle is of correct analysis before it enters the mold for the special casting he is making. If the casting fails to meet exacting requirements it must be scrapped and another one made to replace it. In order to restrict the carbon contents to limits acceptable for readily welded cast steel, and still meet the strength requirements for high pressure ratings, the composition ranges over which a heat of steel may wander have been drastically curtailed, and thus the precision of control in steel foundries has had to keep abreast of these demands. Recently the A.S.T.M. advanced two tentative specifications for steel castings suitable for fusion welding for pressure vessel service at high temperatures. One of the specifications (A216-39T) covers two grades of plain carbon steel for service up to 850 deg. F. and the other (A217-39T) covers four grades of alloy steel for the range 750 deg. F. to 1100 deg. F. The specifications enter into more detail upon chemical composition, heat treatment, testing and inspection than do the two corresponding existing





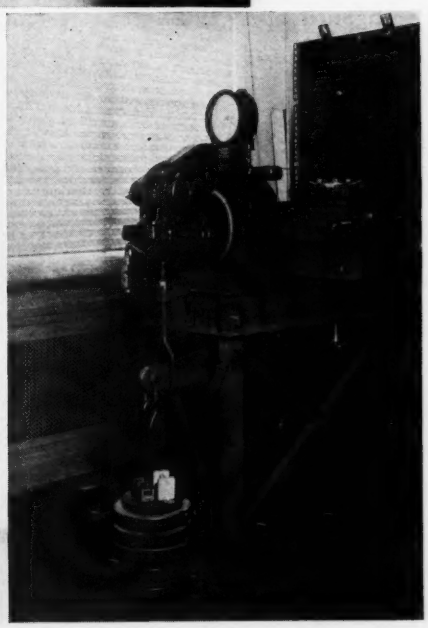


Fig. 5. (Above) Research on the Steam Erosion or "Wire Drawing" of Metals

Fig. 6. (Right) Machine for Measuring the "Relaxation" of Bolting Steels

Fig. 7. (Extreme right) Machine for Research on the Seizure and Wear of Metals

A.S.T.M. specifications for cast-steel valves, flanges, and fittings for high temperature service, (A95-36 and A157-36). Radiographic inspection has become a standard requirement of many of the users of steel castings, and is given recognition in steel casting specifications. It is an interesting commentary to our present review, that these two latter specifications, developed during the decade under discussion, are no longer deemed adequate to fulfill the current needs of the industry.

Flange Bolt Material

While the flanged and bolted joint has yielded to the welded joint in numerous applications to steam power piping, it is none the less indispensible and even more desirable in many locations than welded joints. Metallurgists have been keenly cognizant of the material needs to improve the serviceability of bolted joints at high temperatures and pressures, and definite progress in bolting materials can be recorded. Certainly many of the improvements in joints are attributable to improved design in flanges, and the introduction of the annular metal ring gasket. The essential problem, however, of keeping the joint tight for a satisfactorily long period of time at elevated temperatures, has been to find bolting steels which could stand the imposed loads. In 1930 when steam temperatures were not above 750 deg. F. and the corresponding bolts and studs were not often heated up to as much as 650 deg. F., it was found that oil tempered low alloy steels performed most satisfactorily. Nickel-chromium steel (S.A.E. 310) was one of the first to be adopted to such service, and it continued to give a good account of itself until actual stud temperatures started to stand at 700 deg. F. and go higher. It was then soon appreciated that the creep resistance of this steel, at the stresses imposed in stud loading, was not sufficient. In a short period of time the elastic load developed in pulling up the stud would "relax" to a point somewhere in the vicinity of the pressure load, and leakage would commence. Systematic investigation of many oil tempered alloy steels was undertaken to determine their creep resistance at the temperatures in use. A step forward in high-temperature bolting steel was the adoption of the chromium-molybdenum composition (S.A.E. 4140). Molybdenum showed its excellence in conferring good high temperature strength properties in bolting steel, as it has done in piping and castings. Plain carbon-molybdenum, however, while excellent at the high temperature, does not possess the high elastic strength at ordinary temperatures so essential in the "pulling-up" of a bolt or stud,—thus an additional alloying element, such as chromium is necessary to accentuate high elastic quality. High strength and elasticity became the keynote of the first A.S.T.M. specification in the field of material for high-temperature service (A96-33) in which high tensile properties are the essential requirement and composition is a matter of agreement between purchaser and manufacturer.

Steel Specifications

During the past several years, efforts have been made to relate specifications for high-temperature bolting steels to chemical composition, resulting in A.S.T.M. specification A193-37T which covers eleven grades of alloy steel of varying degrees of merit for service at temperatures above 750 deg F., although the specification by virtue of its title covers steels for application in the range from 750 deg. F. to 1100 deg. F. Actually none of the steels covered by this specification could be recommended for high bolting stresses at metal temperatures of 1100 deg. F. Some of the steels, however, possess considerable merit at temperatures up to 850 deg. F., and one or two stand up at temperatures of 950 deg. F. A difficulty in writing specification A193, which has kept it in the formative stage unduly long, has been the lack of a short-time test criterion which may be used as a guarantee of high temperature creep and relaxation resistance. Although the relative merits at high temperatures between the chrome-molybdenum, nickel-chrome-molybdenum, tungsten-chrome-molybdenum, or "what have

Fig. 8. Group of Welding Operators Depositing Surface Hardening Materials on Valve Parts

you" may be understood by the engineers who have access to all of the data, and know how to evaluate this data in writing a specification for high temperature steel based upon composition and room temperature tensile tests, all of the proprietary composition finding application in the field of service must be included, and the buyer must take his pick. Until a reliable short-time test to show high temperature creep strength and stability is developed, which may be used for acceptance and inspection purposes, a specification for high-temperature bolting materials, entirely usable to the uninitiated purchaser, may not be forthcoming.

One of the comparatively recent developments in bolting metallurgy has been the practice of using a normalized and drawn steel instead of oil tempered, as had been the uniform practice in the past. Studies upon the creep resistance and relaxation of bolts has shown that most alloy steels have markedly superior strength at high temperatures (750 deg. to 1000 deg. F.) when in the coarse grained structure developed by normalizing or air quenching, as against the fine grained structure resulting from oil quenching. In order to successfully apply the normalized structure to bolting, it is necessary to use a steel which will retain, after the necessary "draw-back" or "temper," a high enough tensile strength and elastic limit to withstand the abuse of "pulling-up". A steel developed especially for application in the normalized condition is the chromium-molybdenum-vanadium grade B14 of A.S.T.M.-A193-37T. As normalized, this steel meets all of the physical requirements originally set as standard for bolting in the A.S.T.M.-A96-33 and yet at 950 deg. F. shows a creep strength about four times as great as obtained in Grade B7 (S.A.E. 4140) of the same specification. In high temperature relaxation tests upon actual bolted joints, it maintains loads above the leakage point for a number of years at temperatures where leakage is reached with the B7 type in a matter of weeks. The successful normalized alloy steel bolts at the present steam temperature of 950 deg. F., where oil quenched bolts of all description have failed, stands as a practical advance in bolting material, brought about through metallurgical research, particularly in the field of creep studies.

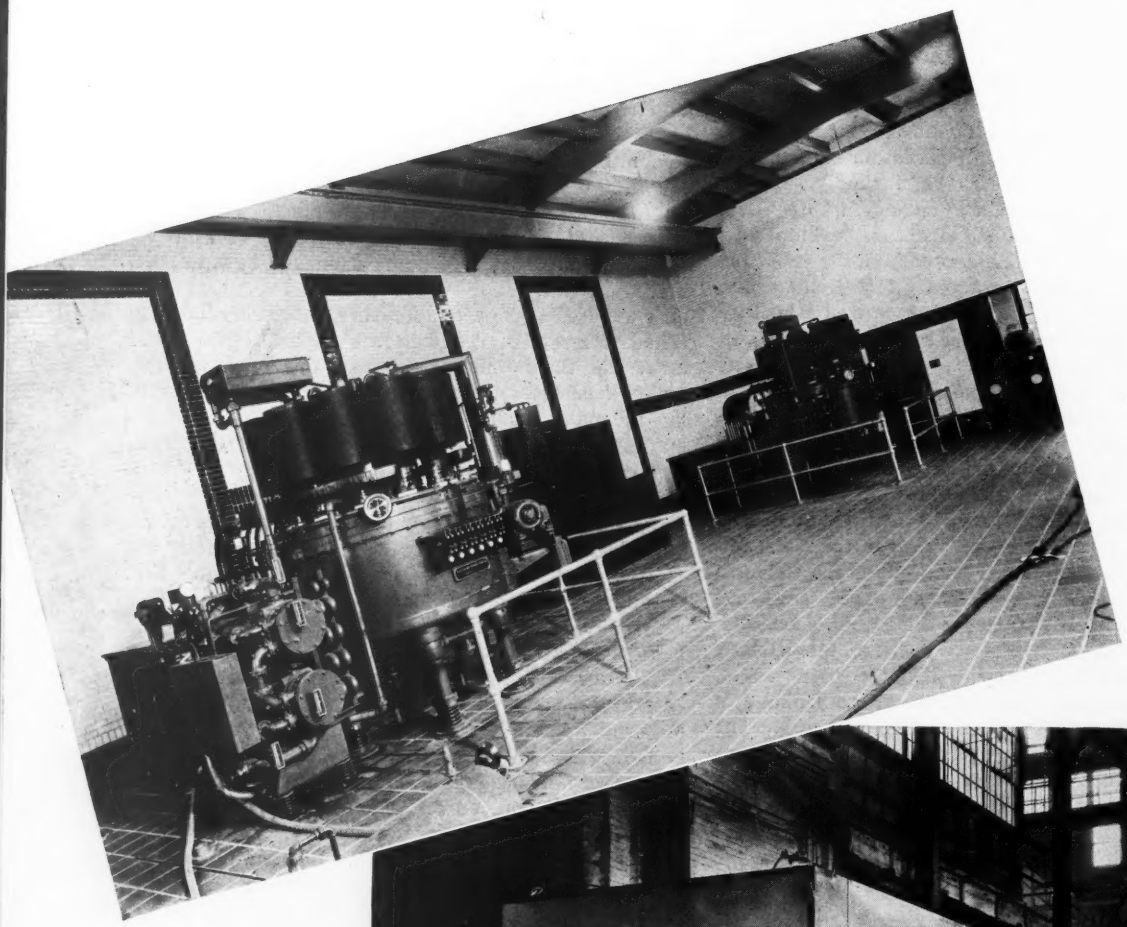
Back in 1930, as steam temperatures and velocities started their rapid ascent, steam plant engineers were experiencing much difficulty with the erosion, scoring and galling of valve seating. Stainless iron had been applied, in the anticipation that its excellent resistance to corrosion would solve the difficulty. It was found that although in globe type valves, where the sliding action of the seating surfaces was not severe, good resistance to erosion or "wire-drawing" was attained, that the hardness of this stainless iron was not adequate to withstand galling in gate valves, where the contact compression is severe on the outlet side when the valve operated under unbalanced pressure. Nitrided steel appeared on the horizon, and due to its great hardness and wear resistance, was hailed as the answer to the galling problem in valves. It was widely applied, and while it did stop galling, even when used in combination with the severely galling stainless steel,—its rather low order of corrosion resistance led to failure through erosion and wire-drawing,—an effect particularly bad in globe valves and other types used for throttling flow. It became apparent that a much more reliable combination of metals for valve seats, where steam temperatures did not exceed 750 deg. F., was stainless iron in combination with nickel-copper-tin alloy.

Resistance to Erosion

Research upon the steam erosion effects upon metals has indicated that the ideal seating material, for temperatures about 750 deg. F. would be one combining (1) the hardness of tool steel, with (2) the corrosion resistance of stainless steel, and above all things, (3) stability of structure over extended periods of exposure to high temperature. As already mentioned, nitrided steel failed because it possessed only the first of these qualities. Stainless steels of the straight chromium type, while having high corrosion resistance, and consequently adequate erosion resistance, and capable of being hardened beyond galling, does not retain the necessary hardness when long exposed to high temperature,—and consequently failed to meet the requirements for seating material upon the third count. Steel of austenitic chrome nickel type (18-8), also of great corrosion resistance, but incapable of the kind of hardness needed, is disqualified on the second count. Fortunately, thanks to powder metallurgy and welding technique, a class of alloys was found which brings together these necessary and sufficient qualities for high-temperature valve seating. The most widely and successfully exploited of these alloys having all requisite qualities, is the combination of cobalt-chromium-tungsten. This type of alloy is of such a character that it cannot be forged or extensively machined on a practical basis. It must therefore be cast to approximate form and is then usually ground to size. Its use as a valve seating material was made possible through the development of a technique whereby it could be overlaid upon a suitable steel base ring or disc, by oxy-acetylene fusion. This "brazed on" layer is then ground and lapped to a suitable seating surface. Such seating surfaces of the cobalt-chromium-tungsten, now find a wide variety of applications where steam temperatures exceed 750 deg. F., and are doing a great deal to promote "fool-proof" valve operation at the extreme temperatures and pressures for which equipment is now required.

There can be little question that today's knowledge of the engineering properties of metals and alloys is definitely more mature than a decade ago. Although startling new discoveries in the way of hitherto unknown combinations of elements and properties may not be apparent, we do have a better understanding of the practical worth of economical materials and we have progressed in the evaluating of their engineering usefulness. It would seem that metallurgists and engineers are becoming more sophisticated in their dealings with the materials of construction, and rather than multiplying their efforts to produce ever new and radically different substances, are devoting an ever increasing effort to rational treatments and applications of those already known.

ADVANCES



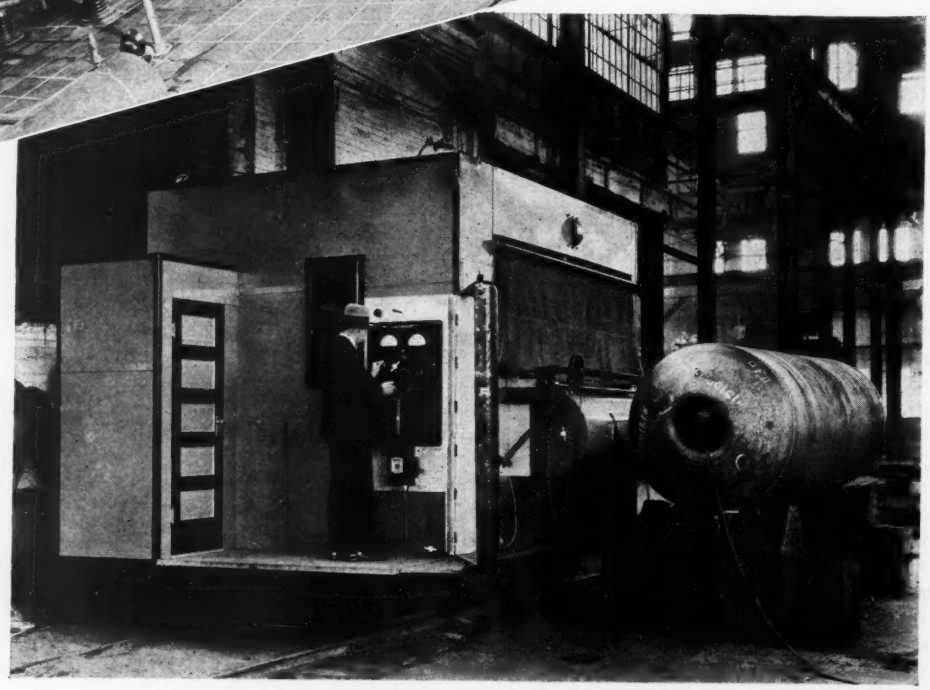


Fig. 1 Above. A modern grid controlled mercury arc rectifier installation. Rectifiers have shown a great increase in use

Fig. 2 Right. The X-ray testing of boilers has revolutionized construction

IN POWER EQUIPMENT

New materials and fabrication methods are forwarding the application of science in the power generation field as is evidenced by many advances made in manufactured equipment.

TO ENUMERATE all the details of advancements that have taken place in the design of power plant equipment during the past ten years would be impossible as well as useless in a review of progress over so long a period in the history of power generation. It has seemed wise therefore to confine consideration of this topic of equipment progress to the general trends in design that indicate improvements that have resulted in higher efficiency, lower maintenance costs, greater reliability in operation, longer life in service, reduced attendance and greater safety to attendants and near-by equipment.

Power plant physical equipment is nothing more than the tools with which the engineer works to accomplish a mentally conceived objective. The objectives must necessarily change with surrounding conditions and desires of customers for power plant services. New services like newly conceived styles are comparatively expensive but, with development and competition, improvements in every direction take place and needs are supplied at continually reducing costs, or, where first costs remain the same, other benefits such as efficiencies, operating expenses and safety take place with development.

During the decade from 1930 to 1940 the improvements that have taken place in the physical equipment of power plants have come about as a result of a better understanding of scientific principles, the employment of newly developed materials, and the application of recently devised fabrication methods. Accidental inventions have not in recent years played a great part in the improvements that have been made. Discoveries have been made that are bound to influence equipment greatly but these discoveries are so deep in science that few of them will be commercially applicable for some time to come. What has taken place has been the simplification and the development toward perfection of operation of power plant equipment. To accomplish these results manufacturers have engaged research scientists and equipped them with laboratories for the study of their manufactured products.

Materials

Materials that enter into construction have occupied the major portion of the researchers' time and as a result nearly every piece of improved equipment has been designed on the basis of material of recent development. Pressure vessels have been strengthened by metals of higher strength. Fabrication by welding in place of riveting has permitted reduced thickness. Parts subjected to corrosion have been made of stainless steels or other non-corrosive metals. Erosion has been met by the use of extremely hard metals. Creep, that quality of ferrous metals that causes them to increase in dimensions under high-temperature service and for many years delayed the use of superheated steam, has been extensively investigated with the result that designers can specify alloys that will safely meet 1000 deg. F. service. The magnetic qualities of irons have been improved so that core losses in electric machinery are reduced and in the other direction permanent magnets are more powerful.

Insulating materials, for both electricity and heat, have undergone many changes making them more convenient to use and more effective in their service with a wider range of application. The use of fiber glass insulation in electric motors, for example, permits operation at a much higher temperature than with inflammable materials, thus giving a higher rating to equipment of this sort.

Several new refractory materials have been developed that not only give better service in boiler furnaces but in combination with water walls and supporting structures, permit a flexibility in design not attainable with the former fire brick, clay and cement.

Plastic materials such as bakelite, cellophane, celluloid and the like are so new in their commercial applications that they are only beginning to be used in the design of power plant equipment. There are many places where these materials are best suited for the purpose but where other materials are being used for no other reason than that they were there first.

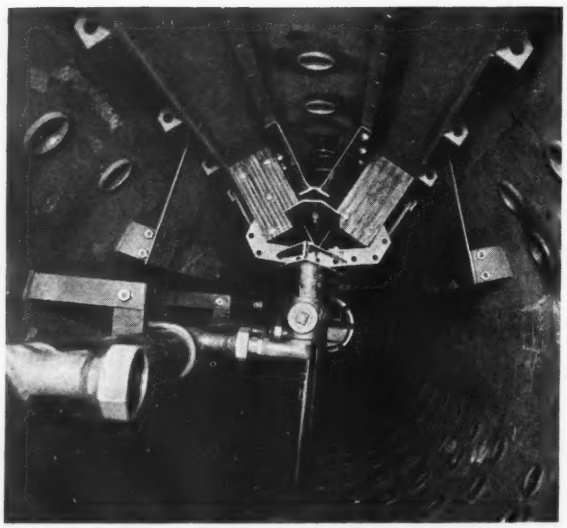


Fig. 3. Steam washer and spray heads inside boiler drum

Several extremely serious fires stimulated the development of non-inflammable lubricants which are being used in services where ordinary lubricants would be a fire hazard. Other developments in lubricants may be summed up as more definite specifications for the various services to which lubricants are put.

Fabrication

At no period in industrial history has there been greater change in the fabrication of materials, the joining together of material parts, the sealing of joints against gas and liquid pressures, than has taken place during the past decade, and power plant equipment has been modified in many ways to take advantage of the new arts.

Table I. Price changes in power plant materials and manufactured equipment over the period 1926 to 1937. Calculated from data supplied by U. S. Bureau of Census

Article	Per Cent Change
Leather Beltings	—11.10
Rubber Packings	—10.51
Lubricating Oil	—10.50
Lubricating Greases	—11.61
Fire Clay Brick	+20.321
High Temp. Cements	—10.10
Steel Boiler Plates	+12.84
Steel Boiler Tubes	+ 7.69
Copper Pipes and Tubes	—11.1
Brass and Bronze Pipes and Tubes	—13.65
Brass and Bronze Pipe Fittings and Valves	+ 8.62
Babbitt Metal	—11.52
Electric Generators	
Direct Current	—18.92
Alternating Current	—39.10
Steam Turbine Gen. Sets	+ 7.95
Power and Distribution Transformers	—12.31
Instrument and Other Transformers	—17.2
Watt Hour and Other Measuring Meters	—12.71
Elec. Indicating Instruments	—17.21
Stationary Motors:	
1—200 hp.	—10.23
Over 200 hp.	—10.48
Mechanical Drive Turbines	—11.01
Steam Boilers, Fire and Water Tube	—10.64
Centrifugal Pumps	—13.56

The art of welding is the most noteworthy of fabrication developments in the power field. Pipe welding by means of the electric arc, acetylene gas flame and thermit processes had reached the practical stage by 1930 but the human element played such an important part in the success of the work that engineers in general were not inclined to recommend these methods for pressure vessels such as boilers. With the development of the X-ray method of testing, however, standards have been formulated and welded boiler drums are no longer a novelty, rather almost the rule. Other methods of testing without destroying the joint have also been helpful; among these are the stethoscopic or hammer test and the magnetic inspection method.

This method of joining boiler plates as compared with riveting has permitted the reduction of plate thickness since riveted joints can never reach the 100 per cent strength efficiency obtainable by welding. As a by-product heat transmission through the boiler metal is increased, thus increasing boiler capacity and efficiency. This method of boiler construction has almost entirely eliminated boiler metal embrittlement that for a number of years remained an unsolved problem. Other advantages of boiler welding may be listed as follows: Permit higher pressure with equal drum thickness; reduces drum weights; permits shorter drums; facilitates sealing against gas leaks; simplifies manhole design; simplifies nozzle attachments; eliminates leaks at joints; reduces mud pockets in h.r.t. boilers; reduces dangers of fire cracks.

Welded steel plate condensers were first used about 1929 and have grown continuously in popularity ever since. They are reported as lower in first cost than the cast-iron construction which prevailed, stronger construction, lighter weight, spring supports may be eliminated, field costs for erection are lower, better and more flexible design is obtainable, many gasketed joints are eliminated, exhaust connection and shell can be made in one piece and repairs are more easily made.

With pipe welding a proven success, manufacturers have developed fittings of all kinds especially for this type of fabrication. These include ells, tees, blanking heads, saddles, sleeves and valves. Contributing to the success of welded pipe joints has been the development of electric annealing methods now being extensively employed. For low-pressure, low temperature service solder fittings are being extensively used. Their advantage is in the ease with which joints can be made without threads. Threaded joints for smaller piping are still the most commonly used and more convenient fabricating tools have been developed.

Advances have also been made in sealing methods made necessary by the use of higher pressures and temperatures. Flange standards have had to be revised and some form of metallic gasket is almost always used in high pressure service. In addition to many changes made in the forms and composition of fabric, asbestos, rubber and other pliable materials used in gaskets, several forms of cement have been developed in recent years for the purpose of sealing joints between metals.

The problem of making permanent seals is usually quite simple compared with that of preventing leaks between moving parts such as around pistons and piston rods, valve stems, centrifugal pump shafts, turbine shafts, past valve seats and similar places. Many ingenious and effective mechanical packing designs have become standard in the past decade.

Boilers

The outstanding changes in steam cycles which are of recent development called first for changes in boiler and boiler room equipment and developing the tested and proven equipment into commercial standards that could be depended upon to perform safely and economically, and that could also be manufactured and sold at a cost that would make the new cycles so economical they would prove attractive to plant owners.

Although former boiler room design practice usually gave first consideration to the selection of the boiler and its design, present practice trends toward giving first consideration to the furnace and the burning equipment, as this section of the unit influences

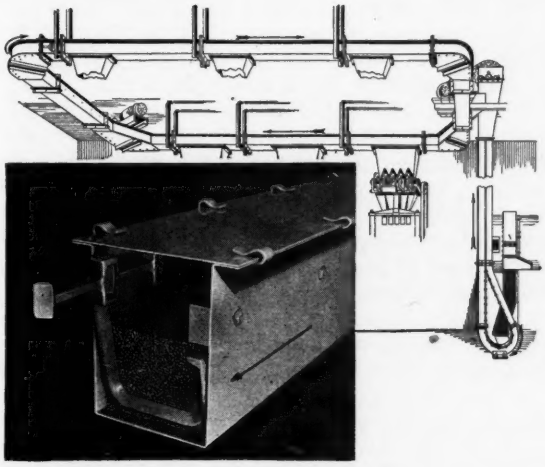


Fig. 4. Run around conveyor

to a predominating extent the operating efficiency obtainable. Here attention must be given to the ash-fusion temperature of the coal and the slag accumulating characteristics of the method of burning and boiler tube arrangement. Boiler furnaces in modern installations are nearly all designed with water-cooled walls even in the smaller units. There are, however, plants where air-cooled walls can be used satisfactorily and with less complication to the boiler design which illustrates the desirability of giving first consideration to the furnace.

At times, the shape of the furnace, which is governed by site limitations, character of fuel and operating conditions, will determine whether a sectional header or bent tube boiler is the more desirable. Steam drums are the next consideration, their diameter being determined on the basis of steam volume and liberating surface depending upon the operating pressure and water conditions. Although a maximum in the low 90's has been secured, in average utility plants the steam generating efficiency is around 85 per cent, corresponding to about 400 deg. F. exit gas temperature. The heat absorbing surfaces used to reduce the gases to this flue gas temperature are usually made up of boiler, superheater, economizers, air preheater and water walls. The relative amount of surface of these parts of the unit varies widely with the designer's individual ideas.

Boiler Accessories

Although the Perkins family experimented back in 1825 with and built boilers for steam pressures as high as 1600 and 2000 lb. per sq. in. and temperatures of 1200 deg. F., the commercial use of superheated steam had to await the development of suitable lubricants for engines. Strangely enough in our own day engineers were delayed in using the extremely high steam temperatures by the lack, commercially at least, of another material, this time it was steel. Alloy steels that will withstand the desired temperatures are, however, now available commercially. The most noteworthy feature in regard to superheater progress, aside from the use of high-pressure, high-temperature steels, is the location which they occupy in the boiler unit and the methods used to control the steam temperature within the required limits. This has been accomplished by careful calculation and proportioning of heating surfaces employing both radiant and convection heat and regulating the flow of gases by means of dampers.

Economizers as a unit apart from the boiler have almost disappeared from the market, their function being performed by a section of the boiler. To decrease the size or, the equivalent, increase the heat absorbing capacity of these low-temperature elements, fin tubes have been used in some designs, since in some installations the bare tube heating surface in the economizer

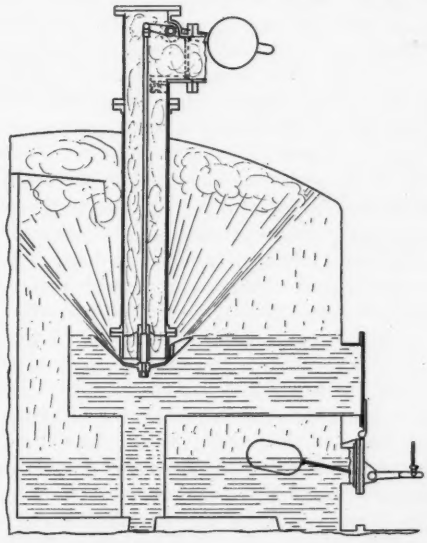


Fig. 5. Atomizing method of introducing exhaust steam into direct contact heater

section ranges as high as 67.5 per cent of the total heating surface of the steam generating unit. These fins of cast iron also protect the steel tubes from external corrosion, in some cases a coating of lead is used for this purpose. Internal corrosion is inhibited by removing the oxygen from the feedwater.

Considerable competition exists between the economizer and the air preheater since both function as heat reclaimers in the flue gas passage. The air preheater is the newer of the two elements and has had to prove its economic advantages in actual installations. Each has its limitations, principally from the economic view point, and in many cases both elements are installed to advantage in operation. Although some changes have been made in the details of design the three types now in common use—plate, tubular and regenerative—have been employed almost ever since preheated air has been used for combustion. Several years ago a regenerative preheater was given a scroll design, roller bearings were added and the lubricating method was improved, resulting in a 20 per cent increase in capacity.

Considerable study has been given to the delivery of clean steam by the boiler and one of the devices employed for this purpose is the steam washer, several recent designs of which have been developed. The principle involved is usually some means of passing the steam leaving the boiler proper on its way to the superheater through a spray of the incoming feedwater. Other devices take the form of separators that intercept the moisture allowing only dry steam to be delivered. Most of these devices have come on to the market during the past decade as a result of studies dealing with causes of scale formation on turbine blades.

Another method of attacking this problem, is by reducing the boiler water concentration by means of continuous blowdown systems several of which have been developed or improved in recent years.

Fly ash and the flue gas nuisance are subjects that are very much under discussion at the present time. Methods of washing the gases free of ash have been greatly improved in recent years and some new electrolytic methods have been developed that are extremely effective. Removal of sulphur dioxide from gases, while not impossible from a scientific standpoint, has not been accomplished commercially with such economic success as to be attractive to plant owners.

With increased furnace ratings temperatures went up thus placing severe strains on the refractory and as a result many changes have been made in the designs of walls and arches and several entirely new materials have come into the refractory field. One of these, marketed under a trade name, is of the monolithic type, is prepared by mixing with water and poured into place without ramming, it crystallizes to nonporous hardness and is suitable for temperatures up to 3200 deg. F. For use in furnace walls along the clinker line, silicon carbide has been developed into brick form. Since it is nonporous, clinker will not adhere to it. Some engineers are using refractory cement in place of fire clay as they find it reduces furnace upkeep. Several manufacturers have designed steel supporting structure for refractory brick walls and arches and providing passages for cooling with air subsequently used for combustion. Water walls have done much to reduce the upkeep expense of furnace walls and definite improvements in designs have come into use during the past decade, one of these being what is known as the stud tube.

Fuel Burning Equipment

From the very smallest, suitable for even residential purposes, to those of immense size serving high capacity power boiler, stokers have undergone many changes that have adapted them to a wider range of fuels but, more important, their efficiencies are higher due, in many cases, to the use of better combustion control methods. Electro-hydraulic methods of driving have improved regulation, the use of roller bearings and better lubricating methods have reduced friction losses, stoker iron losses have been reduced by changes in tuyere designs and the use of metals that will withstand higher temperatures. One of the most outstanding developments is the water-cooled underfeed stoker for burning coals that clinker at low temperatures. Another development of recent years is the pneumatic spreader type that, by means of air currents, delivers crushed coal to furnace grates through properly shaped nozzles. A new technique of burning lignite on forced draft chain grates has been used whereby a large percentage of the fuel is burned in suspension by subjecting the fuel bed to a blast of air from one of the six zones.

The unit system of firing is used almost exclusively in pulverized coal power plants, having displaced the storage system which was the pioneer. This change was made possible by the development of more reliable pulverizers since a failure to supply fuel continuously to the burner would be a very serious fault. The fundamental principles of pulverizers have not changed substantially, but development has proceeded along the lines of perfecting of details such as bearings, materials used, feeding mechanisms, driving means, and an almost universal use of preheated air or flue gases for drying the fuel and transporting it to the burners.

From the nozzle, straight blast type of burner with which pioneering was done in power boiler furnaces, practice has turned completely to the turbulent type

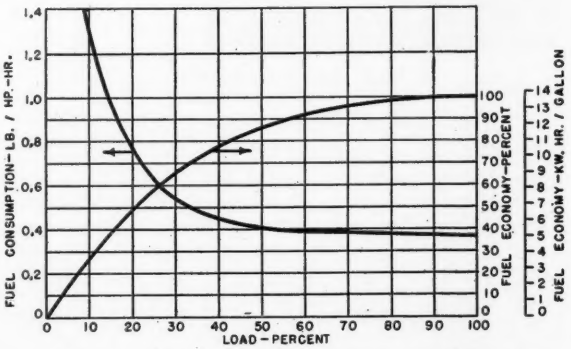


Fig. 6. Variation of fuel economy with load as obtained from a typical modern Diesel engine. From a paper by P. H. Schweitzer before the A.S.M.E.

of burner that gives a mushroom shaped flame. This change has permitted a vast reduction in furnace volume, making pulverized fuel applicable in more limited quarters and to smaller boilers. It has also simplified and reduced the cost of boiler construction. To give a plant the advantages of a choice of different fuels, combination burners are now standard products which are capable, with slight adjustment, of burning

pulverized fuel, oil or gas either singly or in any desired combination. Mr. Sherman's article on other pages of this issue goes more fully into the details of fuel burning technology.

Some changes have taken place in fuels available for power generation but coal, oil and gas still predominate. Petroleum carbon is used to a very limited extent, sludge gas from sewage treating plants is being economically used as fuel for gas engines, and promising experience has been had with black liquor by-products from paper mills.

Fuel and ash handling equipment has advanced considerably in details of design. Roller bearings have been applied to belt conveyors and modern methods of lubrication have cut friction losses. Means of conveying coal, ash and cinder accumulations by air currents have progressed as they offer advantages in simplification, costs and prevention of dust in the atmosphere. The hydraulic method of conveying ash and clinker from furnaces is being used more extensively being particularly applicable to slag-tap furnaces. Two fundamentally new types of conveyors have come into practical use during the past ten years. One of these works on the principle of drawing a chain fitted with prongs through a closed chute filled with the material to be conveyed. The other resembles a large rubber hose which runs over sheaves like a belt. This tube is split into halves lengthwise, the two halves being held together by an interlocking tongue and groove arrangement and a twist in the tube. Loading and discharging is done by separating the halves and closing them again as they travel over special arrangements of sheaves. Both of these new conveyors are flexible in application, almost as convenient as piping.

Table II. Preferred standards for steam turbine generators as recommended by the sub-committee on Standardization of the National Defense Power Committee. Participating in the conference were seven representatives of the Federal government, 12 representatives from three manufacturing companies and three representatives of the electrical utilities

CONDENSING TURBINES

GENERAL: All sizes: Back pressure 1" or 1½" Hg. abs.; short circuit ratio 0.9; generator voltage 13,800; excitation voltage 250

Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	75,000	100,000
Speed, r.p.m.	3,600	3,600	3,600	3,600	3,600	3,600	3,600	1,800	1,800
Throttle pressure, lb. per sq. in. ga.	650	650	650	850	850	850 or 1,250	850 or 1,250	850 or 1,250	850 or 1,250
Throttle temperature, deg. F.	825	825	825	900	900	900	900	900	900
No. of extraction openings	3	3	3	3	3	4	4	4	4
Temp. at extrac. openings 10 deg. F. at rated output	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290	170/225/290/350	170/225/290/350	170/225/290/350	170/225/290/350
Turbine capacity, % of kw. rating	125	125	125	125	125	125	125	125	125
Power factor	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.	Hyd.

SUPERPOSED TURBINES

GENERAL: All sizes: 3600 r.p.m.; throttle pressure and temperature 1250 lb./sq. in. ga., 925 deg. F.; back pressure 200-300 lb./sq. in. ga.; short circuit ratio .09; generator voltage 13,800; Excitation voltage 250.

Rating, kw.	10,000	12,500	15,000	20,000	25,000	35,000	50,000	60,000
Turbine capacity, % of kw. rating	111	111	111	111	111	111	111	111
Power factor	0.8	0.8	.08	.08	.08	.08	.08	.08 or .09
Generator cooling	Air	Air	Air	Air	Air or Hyd.	Hyd.	Hyd.	Hyd.

Pumps

To meet the demands of the new power cycles, boiler feed pumps have had to be redesigned for higher pressures and higher temperatures. This has required the solution of the problems of axial balance, prevention of leakage through the casing and running joints and along the shaft, and the avoidance of distortion. Standard pumps for this purpose are now available for pressures up to 1600 lb. per sq. in. and water temperatures of 300 deg. F. Among improvements noted in pump designs are the applications of ball bearings, sealed and lubricated stuffing boxes, wearing and erosive parts made extra heavy or of special metal, acid handling pumps have pump ends of nickel-chromium-molybdenum steel with other parts of specially treated steel coated with chlorinated rubber. Self priming methods have been applied to a number of designs.

Feedwater heaters had reached the standard design stage long before the period of high pressure cycles began so that from the standpoint of operating principles not many changes have been made. A great amount of study, however, has been given to problems connected with extraction heaters used for heating feedwater with steam bled from various stages of turbines. These have had to do with the number of bleed points, the choice of pressures, the arrangement or layout of the system, the choice of types between closed and direct contact, the methods of venting the piping and pumping system, the insulation, and the selection of instruments necessary to secure best operation. Standard equipment has been made available for all of this work. For the higher pressures and temperatures, however, some manufacturers have resorted to the use of forged steel and have followed the general trend toward welding in construction. Deaerating feedwater heaters are used extensively for removing oxygen content from the water to reduce its corrosive action, and new methods of atomizing water with steam to effect deaeration have been incorporated in standard designs.

One of the necessary provisions which has come into use with the new cycles is the desuperheater, a device in which water is sprayed into steam in order that its temperature may be held at the proper point without loss of heat. Desuperheating equipment has been found necessary in topping plants and others where high-pressure, high-temperature steam must, at times, bypass the high-pressure turbine to the lower pressure units. Several manufacturers have developed standard designs of equipment to accomplish this purpose.

Steam Turbines

Numerous details in the design and construction of steam turbines have been changed during the past decade that have made them more reliable and more efficient in operation. Steam pressures and tempera-

tures were definitely on the upswing but this trend seems to be due for a pause at the present time, though of course pioneer plants are exploring the economic possibilities of extending the practical limits of both pressures and temperatures.

Fundamental principles of turbines have not been changed. Speeds of the largest turbines have reached 1800 r.p.m. with 3600 r.p.m. units increasing in size. This is the limit set by the present standard electrical distribution system of 60 cycles per second. Capacities of turbines have been held down in large measure by the physical limitations of the exhaust end blading but leaving losses have been so improved that capacities as high as 100,000 kw. are being advocated. Here again lack of suitable metal delayed progress, for the blades were subject to such erosive action that they would not last. This difficulty, however, has now been satisfactorily overcome by the use of alloy steels, higher superheat temperature and means for drawing off moisture from the lower stages of the turbine.

Improved metals are playing their part in steam turbine development not only for blades, for which the selection varies with the stage location, but also the shaft, the drum and the cylinder as well as piping, valves and other parts.

Moisture losses have been reduced, thus bringing the expansion line more nearly adiabatic; improvements in governing systems have been reported among other means for maintaining constant pressure at bleeder points, at the same time varying admission of steam to the turbine to carry the electrical load.

One of the most significant proofs that engineering thought is crystallizing in regard to turbine design is the adoption of standards by the National Defense Power Committee for steam turbine generators. These standards are intended to be progressive and, consistent with the fundamental purpose of expediting production and installation of power generating equipment, are intended to permit technical and economic developments. The committee advises that these standards should, at least annually, be reviewed to determine whether advances in the art call for specific modification. The preferred standards for seventeen sizes of condensing or topping turbine generators from 10,000 to 100,000 kw. rating are given in the accompanying table. These were adopted about a year ago.

Definite action of this sort by authoritative engineering bodies is a distinct economic advantage to the field, reducing to a minimum design and manufacturing costs. Small turbines used largely for auxiliary drives have long been standardized in design, higher temperatures and pressures, however, have resulted in refinements having to do with choice of materials and accuracy of control. Accompanying the unit itself has come marked progress in the development of reducing gears to adapt the turbine speed to that desirable for the driven unit.

Steam Engines

For small utility and industrial, institutional and office building plants as well as for many auxiliary services around large power plants, the reciprocating steam engine, of which the uniflow is the most recent type, has a field that has not been taken over by other units. In this field, and it is large in number, steam pressures seldom exceed 200 lb. per sq. in., with superheat, if any, about 100 deg. Condensing and compound engines have been superseded quite generally by turbines, but the simple steam engine exhausting to the heating or process systems is high in economy, extremely reliable, and low in upkeep and depreciation costs. Here again changes over the decade have been in details rather than principles. Bearings and lubrication methods have been improved; more satisfactory speed control systems have been worked out for specific purposes; new, more suitable metals are being used for such parts as piston rings, valves, governor springs, bearings, shafts and rods. Manufacturers have adopted their own individual standards and are offering better products than could be secured ten years ago.

Condensers

Tube arrangements and construction details of condensers have varied with the ideas of various manufacturers without startling results. The outstanding general trend has been toward shells of steel plate and welded joints. Alloys having higher heat conductivities also add to their effectiveness and records have been made for capacity. One unit reported having 113,000 sq. ft. of surface in a single shell.

In an attempt to eliminate air and erosion, one manufacturer is marketing a device that consists of a perforated screen plate placed in front of the tube sheet on the inlet end of condensers for the purpose of prolonging tube life. The circulating water is broken up by passing through the screen openings and this agitation is said to liberate the air which rises up under a division plate and is carried off by an air ejector system. The screen is of a specially selected electrolytic metal which diverts galvanic action from the tubes to the easily replaced screen.

Condenser auxiliary equipment has undergone some changes in that it is an increasing practice now to remove air and noncondensable gases by means of steam ejectors, the steam used for this purpose is condensed in an auxiliary.

Diesel Engines

Diesel engines have made progress in the direction toward standardization. Several new lines of lightweight, high-speed engines and considerable improvement in heavy-duty types of oil and gas engines have been reported. Performance of modern Diesel engines has been improving with perfection of details so that fuel consumption has reached as low as 0.35 lb. b.hp.-hr. in heavy duty power engines of American manufacture, while some foreign engines have been reported as securing 41 per cent thermal efficiency.

Some differences of opinion have existed among designers as to the relative merits of two-cycle and four-cycle engines, also the single acting and double acting. At present two-cycle engines for the larger units are considerably more common with about an even number of single and double acting engines in the class above 1000 b.hp. None of the double acting

engines are built for four-cycle operation. Taking into consideration only capacities, single-acting engines are chosen because of simplicity and accessibility, while the double-acting type requires less space and a smaller number of cylinders for a given power output.

Standardization of many of the component parts of Diesel engines, employing the products of specialty manufacturers, has led toward simplification of design and centralization of control. Some of this progress has been made possible by the application of alloy materials and welding and precision manufacturing methods. Advances which have been noted are controlled pressure lubrication, fuel injection methods, combustion, better scavenging, means for obtaining cleaner fuel, supercharging, the employment of an auxiliary combustion chamber to produce turbulence and silencing exhaust noise.

Speeds have been increased; weights per horsepower capacity reduced; greater unit capacities are

Fig. 7. Metal enclosed cubicles used to control power house auxiliaries

obtainable; space requirements have been reduced; demand for small engines has increased; gas-Diesel units have been developed and the demand is growing; designs are incorporating more of the accessories in the engine enclosure; welding is used more extensively in construction; control is simplified; higher mean effective pressure is obtainable; use of exhaust steam is becoming more common; automatic starting and stopping is broadening the field for Diesels.

Diesel engine power cost tables for 1938 compiled by a committee of the American Society of Mechanical Engineers show that the average fuel economy in gross kw-hr. per gallon of fuel oil is about 9.5 at 50 per cent plant running capacity factor and about 13.9 at 100 per cent plant capacity. A 20 per cent variation on both sides of this figure would represent the economy in about 90 per cent of all plants reporting.

Interpreting a similar report for 1937, Professor P. H. Schweitzer of State College came to the following conclusions on oil engine economy: 1. Engine load has a great effect on both fuel and lubricating oil economy; 2. Engine type has a great effect on lubricating-oil economy and a small effect on fuel-oil economy; 3. Year of manufacture has a great effect on both fuel and lubricating-oil economy; 4. In both cases the improvement is wholly due to advance in design and construction; 5. Engine size has practically no effect on either fuel or lubricating-oil economy; 6. Engine speed has practically no effect on either fuel or lubricating-oil economy; 7. Fuel gravity has practically no effect on fuel economy; 8. Other factors may have some small effect on fuel and lubricating-oil economy but they have not been sufficiently investigated.

His analysis also shows that a large number of the same identical Diesel engines over a period of five years have even improved their lubricating-oil economy by some 25 to 30 per cent.

Hydraulic Turbines

After many years during which hydraulic turbines changed but little in design, the adjustable blade runner was devised and came into practical use about ten years ago with an increasing number of installations up to the present time, as this new principle has made it economically possible to develop the power of a number of low-head streams that formerly were allowed to go to waste. This stimulus and a policy adopted by recent national government administrations to develop available water power sites at public expense as social as well as economic projects has greatly extended the use of hydraulic turbine units. The immensity of several of these projects and the units built to convert the water power into electric power overshadows all former hydroelectric projects in this country.

Design and construction of the smaller hydraulic turbines has followed in lines parallel with other power equipment in that newly developed metals and welded construction are used extensively. The large units are all specially designed and defy general description that would point to trends of practice. It is noted, however, that corrosion resisting steel is used for certain parts subject to wear and corrosion such as the main shaft sleeve, on water lubricated bearings, at gate and runner clearances. Stainless steel welding is extensively used to prevent pitting. Rolled steel is taking the place of castings in many cases. Babbitted oil lubricated bearings served by a unit type oiling system is common practice with Francis turbines while propeller type runners are usually water lubricated, the bearing metal being lignum-vitæ, rubber vulcanized to bronze strips, or some newly developed composition material.

Piping

When about ten years ago steam temperatures and pressures found favor among designers of power plants, one of the unsolved problems was the selection of pipe materials that would withstand the extreme conditions that were desired. Until about this time commercial requirement for wrought-iron and wrought-steel pipe were fairly met by the three schedules for pipe known as standard weight, extra strong and double-extra strong that came into use in 1886. The changed condition, however, brought about a thorough study of the whole problem by the American Standards Association in cooperation with

numerous trade associations, technical societies and government departments which has resulted in the approval of a new standard for Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing. The use of this standard, which has been given thorough tests in practical application over a period of three years, should result in considerable saving in cost and convenience to manufacturers and user industries.

Newer methods of manufacture have made it possible to reduce wall thickness without a loss in strength. The new standard consists of ten weight and thickness schedules running from the lightest to the heaviest pipe commonly used.

In general progress in piping and fluid control equipment may be summed up in two words—materials and fabrication. Materials have been developed, many of them within the last ten years, that are suitable for handling any of the liquids, gases and vapors used around power and industrial plants at the desired temperatures and pressures without excessive deterioration. The art of fabrication by welding has now become an established practice and has caused the development of fittings of all kinds designed especially for this method of joining piping. There are on the market today pipe fittings for screwed, flange, welded and soldered connections, thus giving considerable flexibility to the choice of method each of which has its field of application pretty well defined.

In the design of valves there seems to be no end to the choice of materials used for bodies and trim, and these manufactured products are now in commercial production so that special designs are seldom necessary for any power plant service. These too are made up for the common methods of fabrication. During the past decade numerous announcements have been made by manufacturers of valve products suitable for the severe service demanded by the high pressures and temperatures that have come into widespread use. Among them are those suitable for 1000 deg. F. and 2500 lb. per sq. in. pressure, some with extremely hard metal for seats and discs to resist erosion and corrosion, some have rubber lining used for corrosive and abrasive materials. Not only the materials but in many lines the forms, proportions, packing methods and other features have been modified to meet with standard products the more specific needs of modern industry at prices that are well within economical plant design.

In like manner expansion joints and traps have been adapted to the new conditions, and new flange designs and forms of gaskets have come into common use.

Electrical Equipment

In none of the other fields of power equipment have improvements, changes in design, and development of new fundamental principles been so numerous and so outstanding as in that employing the electrical science. Explorations into the structure of the atom which had been going on in laboratories and radio work for a number of years suddenly, as far as the power engineer was concerned, developed applications in power equipment that have been extremely beneficial.

Studies of the electric arc and its supression by deionization have done wonders in bringing about quicker acting air and oil circuit breakers capable of handling higher voltages and greater currents. The ignitron principle of control for rectifying alternating into direct current has opened up many applications of current control previously non-existant. Electron tubes for converting alternating into direct current and vice versa have extended greatly the uses of electricity for specific purposes with economic results. They have even revived study and experiment with high-voltage, long-distance, direct-current power transmission.

Magnetic alloys, having greatly increased permeability at high flux density with non-aging, low-magnetic loss qualities have been incorporated in the design of generators, motors, synchronous condensers, transformers and other equipment employing metal subject to alternating magnetic flux to increase efficiency, cut down weight, reduce operating temperature or increase rating. Insulating material, both treated fabric and spun glass, have been developed that reduce space requirements, permit higher operating temperatures, thus increase ratings and prolong life of the equipment.

Hydrogen cooling for generators and synchronous condensers has found its place in power plant practice and is used as a means of increasing efficiency and reducing size of nearly all the large units now being installed. Size and weight of units has also been reduced by increasing the speed which has permitted many of the larger generators to be constructed for 3600 r.p.m. operation.

Illuminating principles of today are revolutionary compared with ten years ago. Filament and arc lighting units are giving way for specific purposes to vapor lamps and just recently to the fluorescent lamp which not only is extremely more efficient but operates at low temperatures and may be designed for almost any color. It has no filament. The electric energy is first transformed into heat and then into radiant energy. An electric discharge is created across an atmosphere of ionized mercury vapor, the inside walls of the light tube are coated with salts called phosphors that transform ultraviolet energy into visible radiation.

Standard motors now available incorporate such improvements as ball or roller bearings; dust, moisture and explosion proof enclosures; copperspun rotors; welded frames; and thermal overload switches. Experience is being gained with electron tubes used to convert alternating into direct current for exciting generators and synchronous motors. Mercury arc rectifiers are rapidly extending their service to industries as substation equipment of large capacity.

All the way along the line of manufactured equipment, progress has been toward the use of the latest materials known to industry, the application of scientific principles recently coming from the research laboratories, simplification in designs, application of mass production methods wherever practicable to the end that more reliable and economical equipment may be available to meet the ever increasing specific demands of industry in competitive fields.

BOILER FEEDWATER TREATMENT 1930-1940

By FREDERICK G. STRAUB

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New methods and equipment for the chemical control of boiler feedwater have come into the field suitable for use in all types of steam generating plants. During the past decade, automatic recording as well as controlling equipment have come into use with beneficial results.

IN 1930, MANY steam power plants were making use of external softening equipment to treat their boiler makeup water. A small amount of secondary chemical treatment was in use. Many plants used internal treatment alone. The external treatment involved the use of the cold process lime soda softener, the hot process softener and the zeolite or base exchange softener. The cold process, relying on the softening of the water in the cold, required a long time to produce a soft stable water which would not cause precipitation in filter beds, secondary zeolite softeners, etc. This time was so long that this type of treatment involved the use of batch treatment in large tanks capable of holding more than 4 hr. supply. Even with such tanks it was often necessary to overtreat and use coagulants in order to produce a stable water. The hot process softener accelerated the rate of reaction so that much shorter retention times were necessary and coagulants were in general not used.

The zeolite or base exchange softeners had the advantage of being operated in the cold. They could be operated continuously with short periods being required for regeneration with salt or brine solution. Even though they gave a water low in hardness, however, they did not reduce the total solids and when used with a high bicarbonate water they caused the introduction of a large amount of sodium bicarbonate into the cycle which in turn caused increased alkalinity in the boiler water. Consequently in 1930, there was a trend toward the use of the hot process softener in preference to the zeolite softener.

In cases involving the use of external softening apparatus the presence of a small amount of residual hardness made it advantageous to use secondary chemical treatment to prevent scale in the boiler. This secondary chemical treatment involved the use of the ortho-phosphates such as mono, dir, or trisodium phosphate, and organic extracts such as quebracho, cutch, tannins, etc.

The use of internal treatment was in general limited to the smaller lower pressure boilers. The chemicals used were phosphates, soda ash, and organic extracts. The higher pressure plants were using evaporated makeup in many instances so as to keep the total dissolved solids low in the boiler water and to reduce the blow down.

Chemical Control Emphasized

During the interval between 1930 and 1940 the use of more higher pressure high rating boilers along with the necessity for reduction in time of boiler outages has emphasized the importance of proper chemical control of the boiler feedwater so as to prevent scale, corrosion, embrittlement, and carryover. There has been a trend during this time to use higher percentages of boiler makeup water without resorting to much increase in blow down. This has emphasized the importance of reducing the total dissolved solids in the treated water. At the same time it has made it necessary for treatment of large volumes of makeup water so as not to cause difficulty in the operation of the boilers using these treated waters.

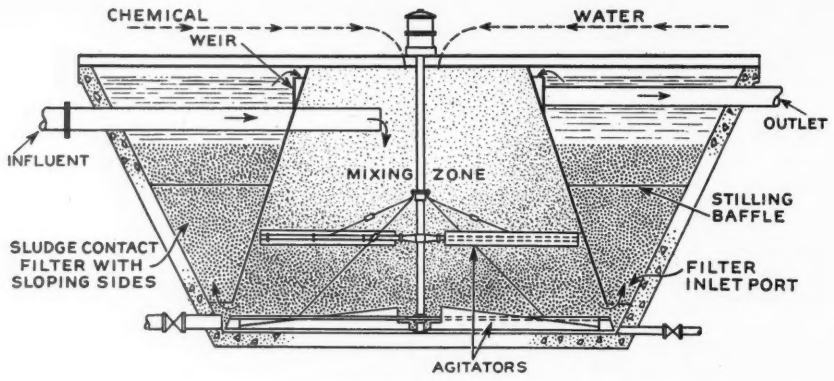


Fig. 1. Precipitator two compartments, the mixing zone and the upflow contact filter with sloping sides

In the external treating or softening of the makeup water there has been major modifications of the cold process, hot process and zeolite softeners which have served to furnish a treated water of a type much better for the modern power plant.

Cold Process Modified

The cold process softener has been so modified that there is a marked increase in the rate of softening. It is now possible to have a continuous flow through a cold process softener with a retention period similar to that in a hot process softener. The effluent from these continuous flow softeners is almost free from suspended solids, and will not cause after precipitation on filters or secondary zeolite softeners. Under these conditions overtreatment is not necessary and the resulting water has a lower total solids and is quite suitable to be used ahead of evaporators, zeolite softeners, etc. Figure 1 and Fig. 2 represent two outstanding developments in the cold process lime soda softening field. With the use of either of these softeners it is now possible to combine the cold process and the zeolite softeners on continuous flow treatment of raw waters without overtreatment of the water in the cold process softener or acid treatment ahead of the zeolite. This treatment is very suitable for waters having high bicarbonate hardness.

This change in reaction rate has been accomplished by taking advantage of the increased rate of chemical reaction which results when the sludge resulting from the precipitation within the softener is thoroughly mixed with the treating chemicals and the water being treated. In these softeners the sludge is agitated by means of revolving paddles or blades at the bottom of the softener. This brings the treating chemicals, the sludge and the incoming water all in intimate contact. The water then flows up at diminishing velocity through a floating sludge blanket. This is accomplished by the design of the softener compartments. The water leaves the sludge blanket almost crystal clear and the chemical reaction is complete. Thus in a comparatively short space of time a clear, soft stable water has been produced in the cold with a minimum of chemicals. A filter is usually used after these softeners, as a precaution, however, the time interval between washing the filters is greatly lengthened. Very little if any precipitation is formed on the filter beds.

The hot process softener has been modified so that in many instances a secondary phosphate treatment is possible in the softener which gives an effluent which is very low in hardness.

Changes in Zeolite Treatment

The older zeolite softener involved the use of the siliceous zeolite containing sodium aluminum silicates. These were not stable in acid or strongly alkaline waters. This made it necessary for close control of the pH value of a water being treated in the older base exchange softeners. A new softening material for use in the base exchange softeners now allows its use in acid or alkaline waters. These bodies are called, "Organolites," "Zeo-Karb," "Exchange

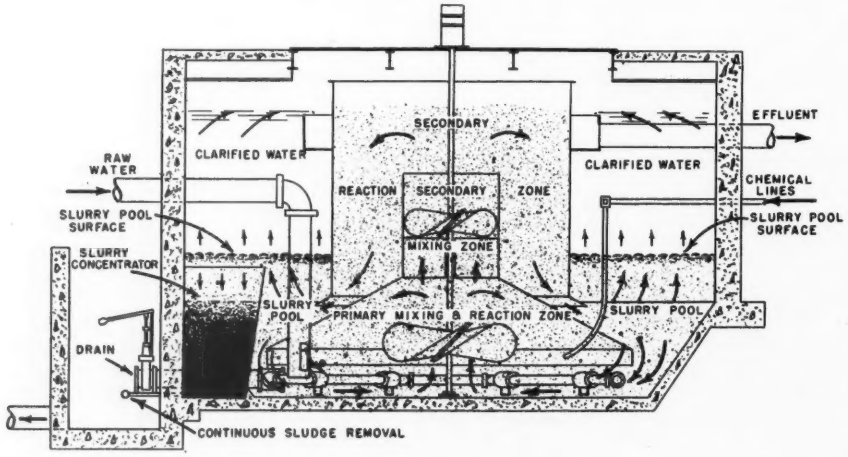


Fig. 2. Cross section of equipment for accelerating water softening process

Filters," "Demineralization," etc. They operated under two conditions, either on the sodium or the hydrogen cycle. They may be used similar to the older zeolites and be regenerated with a salt or brine solution. Under such conditions they are said to be operating on the sodium cycle and they give a treated water having the same composition as one treated with the older type zeolites. They do, however, have the advantage of being non siliceous and thus preclude the possibility of increasing the silica content of the water. They are also more stable over wider range of pH changes than the older zeolites. Under the conditions of the sodium cycle they convert the calcium and magnesium bicarbonates to sodium bicarbonates and the sulfates or chlorides to sodium sulfate or chloride.

If they are regenerated with an acid solution such as sulfuric acid instead of a salt solution, they are said to be operating on the hydrogen cycle. After they have been treated with acid they give an effluent in which the calcium and magnesium bicarbonates are converted to carbonic acid (H_2CO_3) and the chlorides and sulfates to hydrochloric and sulfuric acid respectively. The carbonic acid readily breaks down to form carbon dioxide and water. The carbon dioxide is readily removed by blowing air through the water (degasification). The effluent from the hydrogent cycle is acid in nature and could not readily be used for boiler feedwater. The usual procedure followed is to pass part of the raw water through one tank operating on the sodium cycle, which gives an alkaline water containing sodium bicarbonate. The rest of the water is passed through the hydrogen cycle and the effluent from the two softeners mixed in the proper proportions so as to give the desired alkalinity. The mixed water is then degasified.

The equipment used in the acid cycle must be properly protected so as to prevent acid attack on the metal parts.

The water resulting from the use of a combination sodium and hydrogen cycle will give a reduction in total solids depending on the relation between the bicarbonates and the chlorides and sulfates in the raw water. As the bicarbonates increase, there is more reduction in total solids. At the same time the cost of treatment increases since more sulfuric acid is used. This treatment is in general more expensive than the older zeolite process. The equipment cost is higher since acid resisting coatings must be used and the newer softening materials are more expensive. This increased cost, however, is more than offset in many installations by the reduction in total solids with resulting decrease in blow down and ability to use more makeup.

These new base exchange softeners are low in silica whereas the older type of zeolites had a high silica content. The use of these materials thus prevents the contamination of the treated waters with silica.

During recent years the problem of silica scale formation in steam boilers has become very serious in plants operating at pressures above 400 lb. and at high ratings. The normal treatments used to prevent sulfate or carbonate scale have not prevented the formation of the complex silicate scale. In some instances internal treatment involving the use of finely divided iron has aided by keeping the dissolved silica very low. In general, the trend has been to prevent this type of scale by lowering the silica content of the feedwater. This has been accomplished by the use of proper coagulants at definite pH values in external cold process softeners. In some plants it has been found that these deposits form only in areas of high heat transfer and by changing operating conditions so as to eliminate these spots of excessive heat transfer the scale has been prevented.

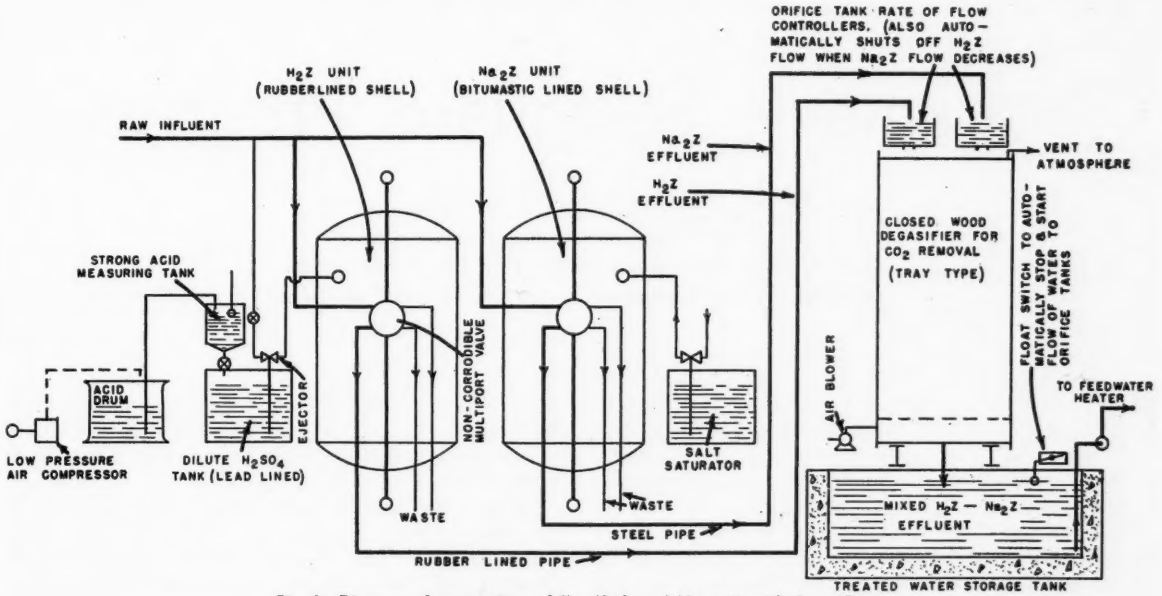

ORIFICE TANK RATE OF FLOW CONTROLLERS. (ALSO AUTOMATICALLY SHUTS OFF H_2Z FLOW WHEN Na_2Z FLOW DECREASES)
H_2Z UNIT (RUBBERLINED SHELL)
Na_2Z UNIT (BITUMASTIC LINED SHELL)
RAW INFLUENT
Na_2Z EFFLUENT
H_2Z EFFLUENT
VENT TO ATMOSPHERE
CLOSED WOOD DEGASIFIER FOR CO_2 REMOVAL (TRAY TYPE)
FLOAT SWITCH TO AUTOMATICALLY STOP & START FLOW OF WATER TO ORIFICE TANKS
STRONG ACID MEASURING TANK
ACID DRUM
EJECTOR
NON-CORRODIBLE MULTIPORT VALVE
AIR BLOWER
TO FEEDWATER HEATER
LOW PRESSURE AIR COMPRESSOR
DILUTE H_2SO_4 TANK (LEAD LINED)
SALT SATURATOR
WASTE
WASTE
MIXED H_2Z — Na_2Z EFFLUENT
STEEL PIPE
RUBBER LINED PIPE
TREATED WATER STORAGE TANK

Fig. 3. Diagram of connections of Zeo-Karb and Na units with degasifier

Secondary Treatment

The use of orthophosphate has resulted in feed line deposits in many plants. This has been prevented in some plants by adjusting the pH value and in other plants by intermittent feeding of the phosphate. Many plants pump the phosphate solution directly into the boilers and thus eliminate this type of trouble. The

use of metaphosphate has prevented these feed line deposits. The metaphosphate prevents the formation of feed line deposits and, if the temperatures are not too high, even stops the deposits in economizers and high pressure heaters. The metaphosphate also has the property of converting to an acid salt at higher temperatures. Thus it reduces alkalinity in the boiler water. It has recently been discovered that the metaphosphate when used in very small amounts such as one or two parts per million will prevent deposits from forming in condensers, heat exchangers, etc., using untreated waters. This treatment should be of aid in reducing operating costs in such types of equipment. Other types of phosphates, either alone or when present with organic materials, and certain organic materials alone have similar properties and are also being used.

The secondary treatment of boiled feedwaters has involved the use of chemical treatment to eliminate the corrosion caused by the small amounts of oxygen remaining after deaeration. Even with deaerating equipment functioning properly there are certain conditions of operation which allow small amounts of oxygen to enter or remain in the system. In order to remove this last trace of oxygen and prevent corrosion, chemical treatment has been used. The chemicals in use are sodium sulfite, organic extracts, iron or ferrous compounds, etc. These chemicals react with the oxygen before the oxygen can react with steel in the system and thus prevent corrosion.

The use of higher pressure along with a higher percentage of boiler makeup water in many power plants has emphasized the importance of the selection of the proper chemical methods for prevention of difficulties. At the same time, the increased pressures and higher ratings of the low makeup stations has shown the necessity of close chemical control of the water steam cycle. This demand has resulted in the use of automatic recording as well as controlling equipment to check as well as regulate the chemical treatments. The modern power plant needs a control laboratory and the services of a man or men familiar with the chemistry involved.

Instruments Safeguard Progress

Extremely important and highly useful instruments have come out of the laboratories to find permanent homes in power plants to such an extent that the 1930's might appropriately be designated as the "Instrument Decade."

PROGRESS in the field of power plant instruments and instrumentation has probably been just a little ahead of other power equipment development for the reason that safety demands every precaution be taken not to exceed limits of conditions set by the designer. So when, for example, superheater tube metals are chosen for steam temperatures not to exceed 900 deg. F. the engineer must be supplied with instruments that will indicate temperatures at critical points with a high degree of accuracy. Likewise pressures, speeds, voltages, electric current, rates of flow, boiler water levels, water concentrations, a hundred and one other conditions all of which must be held within narrow limits of variation and can be known to the operator only through instruments, have demanded that the necessary instruments be available or developed before the major equipment is put into operation. Instruments for refining operation can of course await development pending proof that the new or experimental equipment meets with commercial approval. Safety of operation, however, must be assured as far as it is possible to do so in advance of attempts at experimental operation.

In this field again, the trends toward higher pressures and temperatures have found instrument manufacturers adjusting their standard lines to include those instruments that will fit in with advanced practice. And while they were working on new designs, their older designs have undergone revision making them more sensitive, more accurate, at the same time more rugged and in aesthetic harmony with the usual surroundings.

Among instruments which have been subjected to this class of improvement, announcements have been made during the past decade of pressure gages of the indicating and recording types capable of service at steam pressures 1500 to 2000 lb. per sq. in. and temperatures up to 1200 deg. F., standard water columns for 1800 lb., commercial thermometers for industrial service indicating and recording temperatures up to 1200 deg. F., flow meters for steam pressures up to 2500 lb., feedwater control equipment for pressures up to 1800 lb. per sq. in. So it is evident that instrument manufacturers are in position to furnish industry with all the necessary instruments in standard design for indicating and recording the highest steam pressures and temperatures likely to be used for some time to come.

New Principles

Several new principles have been incorporated in the operation of instruments making it possible to indicate or record data that formerly was difficult if not almost impossible to obtain. For example, instruments are now available for recording the pH value of water and other liquids, electrolytic and

electronic principles are being employed in some of these. Smoke indicating and recording instruments employing the photocell to furnish the impulses that operate the indicating mechanism have been developed and are now obtainable in standard form. Several electronic methods of indicating water level in a boiler are now in use. The electric eye is used in some devices to guard against the dangers arising from the extinguishing of furnace fires. Other means for this same service employ a thermocouple. To reduce inertia and friction, one line of instruments employs a light beam in place of an indicating arm. The light beam is also used to control many processes in industry. The cathode ray oscillograph is being used as an indicator to study the behavior of high speed oil engines.

Flow meters have undergone considerable refinement in design, making them more accurate in their readings and extending their service. Some of these use adjustable orifices to improve accuracy over longer ranges. An escapement type integrater has been incorporated. The inductance bridge principle has been adopted for use with electric type flow meters. Control boards are being simplified by the use of combined instruments. In some cases graphic records of feedwater, steam, air flow and flue gas temperatures are all made on one chart. Several manufacturers have standard draft gage instruments that indicate combustion air and furnace draft pressures at all important points through the boiler setting, in one convenient unit.

Instruments that Control

Indicating and control instruments have, in recent years, been developed not only to test the effectiveness of the water treating system, but in some cases

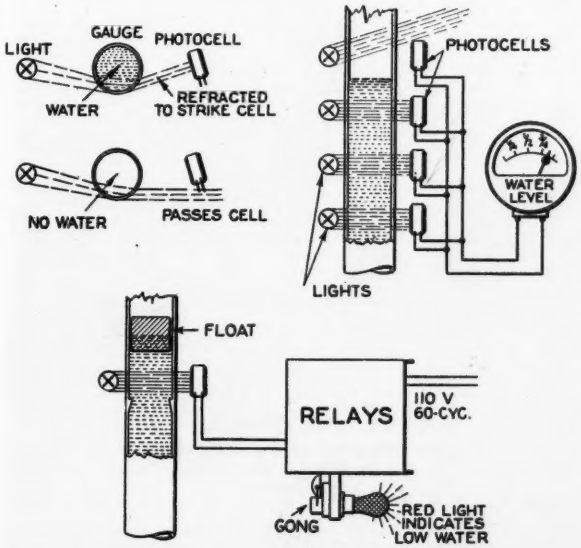


Fig. 1. Diagrams illustrating methods of indicating and controlling water level by means of the electric eye

controls have been incorporated that even operate valves in the back wash system and automatically maintain the hardness of the treated water within established limits. Electrode assemblies are employed

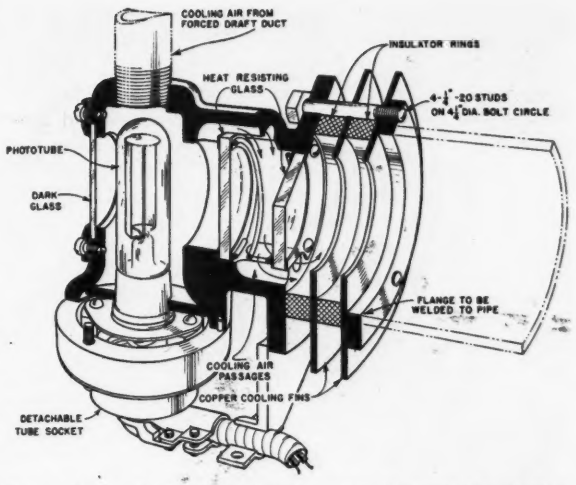


Fig. 2. Section through flame detector of the electronic type showing heat absorbing glass disks, copper cooling fins and path of cooling air

in a meter that indicates the pH value of water and guides the operator in the care of his boiler. Another meter operating on the electric resistance principle indicates the boiler water concentration and is used to indicate when the blowoff valve should be opened. Combined in one instrument, an hydrometer and a thermometer are used in the operation of the continuous blowdown system. The aging characteristics of oils while in use are made known by an instrument which shows the process of oxidation against time.

Automatic control of power equipment is by no means a new feature in power plants but the practice has been steadily growing throughout the years as instruments have improved and their services extended. The mechanical methods first employed have been augmented by hydraulic, steam and air operated equipment, then revolutionized by the use of electric currents and now again by photoelectric means of conveying impulses to relays. There seem to be no scientific limits to the application of automatic controls, all they lack is the power to think and reason. Control equipment for specific purposes is sometimes too expensive for the purpose intended but with standardization of instruments and production methods of manufacture, control systems have become carefully designed assemblies that are now so economical in first costs that many control features are being used in small plants.

In the power plant, the automatic combustion control systems are the most productive of savings and they are the most intricate when a complete system is installed. They became practically necessary when boilers got to be of such a size that several men were required each to maintain only one or two specific conditions in the boiler which often resulted in confusion and lack of coordinated action. From that time on combustion control methods have been extending and improving both in reliability and accuracy.

Recent developments have been initiated in the extremely large high-pressure, high-temperature plants where controls must work rapidly. Success under these conditions has encouraged manufacturers to apply similar methods in smaller plants with results

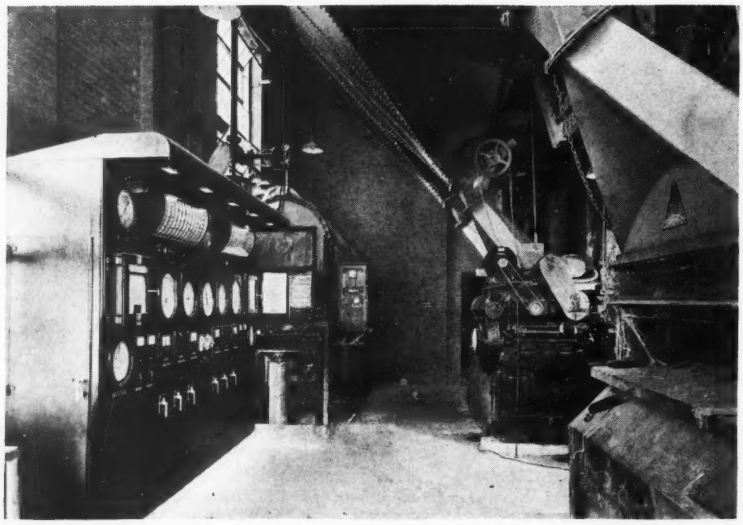


Fig. 3. Instruments and control equipment are essential to the safety and economy of modern boiler plants

that have been economically beneficial. The vigilance of instruments as compared to men has been shown by tests to be from two to five per cent in favor of instruments. These controls, made up as they are of elements for specific service, are applicable either automatic as a whole or in part manual, giving the designer wide liberties in selection for the condition under which the plant is to operate.

Where complete automatic control is not applicable designers are resorting to the provision of centralized control in which the man in charge of operation is provided with remote reading indicating instruments and means for adjusting speeds, flows, pressures, temperatures, etc., in order to secure highest economy under the immediate load conditions. These, too, are extremely flexible in their choice, some providing for control of only individual units, such as boilers, turbines and principal auxiliaries; others centralized control by departments; still others have a centralized control department that supervises all operating conditions in the plant. All these arrangements have called for the development and perfection of remote reading instruments much of which has taken place in the past ten years.

An entirely new phase of instrument service has been inaugurated in recent years which may be described as supervisory. Its application to a number of steam turbine units has encouraged manufacturers to perfect their instrument designs and offer them for application to other equipment. Some of the important instruments developed for service on turbines are: Eccentricity meters, indicate and record shaft accentricity; vibrometers, indicate and record the range of vibration in vertical and horizontal directions at one turbine and one generator bearing; expansion meters, indicate and record axial expansion of turbine cylinder; and noise meter, indicates through an amplifier system the noise produced by the blading and glands, the indicating meter being supplemented with a pair of head phones to provide an audible signal.

Another supervisory system has been developed for the remote control of substation equipment. One application provides for the following operations: Opening and closing of circuit breakers; starting and stopping of machines; raising and lowering of speeds, volts, and gates; obtaining of meter readings; and allows telephone conversations and calling.

In the instrument field there is every indication that: Applications will become more numerous as plant owners learn of the savings which can be credited to their correct use; standardization in manufacture, testing and installation will continue to progress for sometime to come with economic benefits to the industry; control systems built up of individual instruments will come into more general use, broadening their scope in the direction of application in the smaller plants.

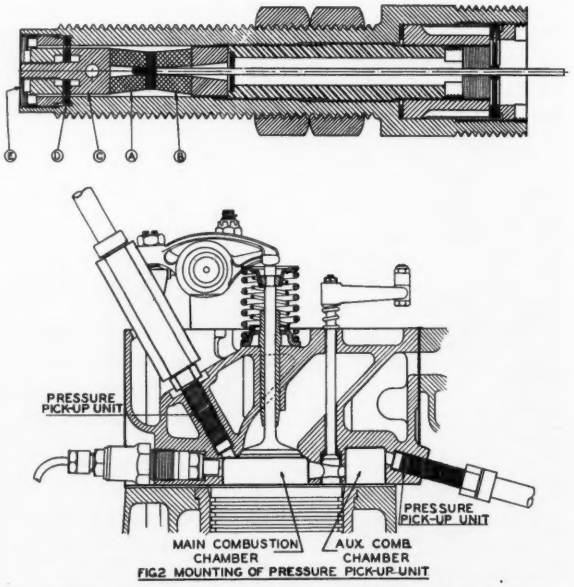


Fig. 4. Cathode ray oscgillograph pressure pickup unit in cross section and as mounted in Diesel engine cylinder head to indicate performance

Two quartz crystals A and B are mounted so that their positive charges are collected additively on the high potential electrode mounted between their inner faces. The shell serves as a common ground. The crystals are locked securely under an initial pressure between the retainer and a supporting column attached to the diaphragm D. Pressures are transmitted up through the column to the crystals. The diaphragm is shielded from the direct flame heat by the protecting column E which maintains a uniform diaphragm temperature even though the temperature of the gases in the cylinder may change from 100 to 3000 deg. F. during a cycle. Since none of the parts move, errors from inertia common to mechanical indicators are eliminated. The mounting also eliminates connecting passageway errors.

Metallurgical Studies Fostered by Engineering Societies

By DR. A. E. WHITE

Professor of Metallurgical Engineering
University of Michigan

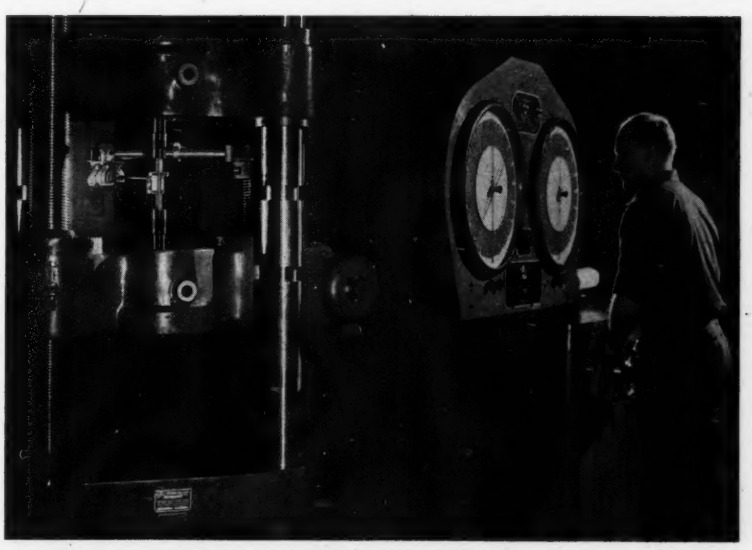
ABOUT 1920, a need for materials to operate successfully at temperatures above 750 deg. F. began to appear. Much was known at that time with regard to the properties of metals and alloys at room temperature, but little with regard to the properties of these same metals and alloys at temperatures above 750 deg. F.

In 1923, Vincent Malcolm saw the need for a sponsored activity to procure information with respect to the properties of metals at elevated temperatures. He, with others associated with him, arranged a program for a "Symposium on the Properties of Metals at Temperatures other than Room Temperatures," which was held at the Spring Meeting of The American Society of Mechanical Engineers in 1924.

At the time of this meeting, a committee on "Effect of Temperature on the Properties of Metals" was formed under the joint auspices of the American Society for Testing Materials and The American Society of Mechanical Engineers. The chairman of this committee was G. W. Saathoff. In 1930, this committee was reorganized with H. J. French becoming its chairman. At a joint meeting of The American Society of Mechanical Engineers and the American Society for Testing Materials, held in Chicago on June 23, 1931, a second "Symposium on Effect of Temperature on the Properties of Metals" was held. H. W. Gillette was chairman of the symposium program committee. Since that date, the Joint High Temperature Research Committee has been extremely active in sponsoring various projects and, in March, 1938, issued a "Compilation of Available High Temperature Creep Characteristics of Metals and Alloys." This publication is at present the most complete source of information available dealing with the properties of metals and alloys at elevated temperatures. The committee has also formulated a standard procedure for short and long-time tests at elevated temperatures. This work has done much toward making it possible to compare the results from various laboratories, for, until these standard test methods were adopted, it was extremely difficult to compare the work of one laboratory with that of another.

During this same period, the American Society for Testing Materials has been most active in the formulation of specifications for materials for high-temperature service. Committee activities started about 1924, with Mr. Malcolm as chairman. A few years later L. W. Spring became chairman and the work was carried forward under his leadership until his death. Since that time the general chairmanship of the high temperature committees has been held by Dr. A. E. White.

At the present time, there are five sections in the high temperature committee, as follows: Section on Pipe, Section on Castings, Section on Bolts and Nuts, Section on Forgings, and Section on Welding Fittings. The chairmen of these sections are, respectively A. E. White, J. J. Kanter, Chester Hacking, J. Hall Taylor, and J. J. Kanter. All of the sections, except that for Welded Fittings, have developed a number of specifications for their respective fields. The Section on Welding Fittings has but recently been formed and is now engaged in the preparation of specifications. Owing to the newness of the field, it has been necessary to revise the specifications quite frequently. For this reason, the High Temperature Committee has been one of the most active ones in the American Society for Testing Materials. Possibly there is no better place to determine what is available in this field than the Standard and Tentative Standard Specifications which have been formulated by the American Society for Testing Materials.



The hydraulic tensile testing machine has played an important part in developing steel. This one records stress-strain diagrams automatically

A DECADE IN

The technique of fuel burning has been and always will be paramount as long as power has to be produced from the process of combustion. No one element could possibly be of greater importance. Fuel is the major item in the cost of operating a steam power plant and whether it is a central station burning 1000 tons a day or a small laundry using only a ton or two the chemical process of combustion is the same for each type of fuel. Like all chemical processes, absolute control is essential if definite results are to be secured. Progress along this line during this decade has been toward perfection of details to secure this control.

THE YEARS from 1930 to 1940 may well be known as the depression decade. With reduced rate of increase in the utilization of power and a corresponding decrease in the rate of expansion of industrial and utility power plants, there have been fewer opportunities for new developments in fuel utilization. The use of power has grown, however, and the closing months of 1939 saw the greatest output of electric energy in the country's history. Each of the new plants, new boilers for topping units, or plant extensions has seen some refinements in the practice of former years and the ten-year period has witnessed a number of innovations. Among these are the continuous slag-tap furnace, the two-stage boiler furnace, the unit or integral furnace boiler, the water-cooled underfeed stoker, zoned air control for underfeed stokers, the continuous ash discharge stoker, the pneumatic spreader stoker, and combination burners in which oil, gas, or coal or combinations can be burned.

The previous decade was the period of the rapid expansion of pulverized coal and predictions of the ultimate passing of the underfeed stoker were common. It is true that tabulations of installations made in large utility and industrial plants show a predominance of pulverized coal and it is true that some manufacturers who are builders both of stokers and pulverizers have recently stated that they do not quote on stokers unless specifically requested. Yet it is also true that the large multiple retort underfeed stoker is by no means passed and has been improved to meet the demands for capacity and economy now set. In the moderate size plant, the underfeed stoker remains the favored equipment for burning coal and more coal is burned today on underfeed stokers than by any other method. Traveling-grate stokers continue to have their adherents particularly for coke breeze, anthracite, and coals whose ash clinkers badly. The spreader stoker has had a remarkable growth most of which occurred since 1930.

Pulverized Coal Advances

The discussion of the relative merits of the bin and direct-firing systems belongs to the previous decade and direct-fired systems are the rule today. This rule is not without its exception to furnish its proof, however, as the Port Washington station of the Milwaukee Electric Railway and Light Company installed a bin system in 1935. No new principles of pulverization have been discovered but the ball mill, the roller mill, the ball-race mill, the attrition mill, and the high-speed impact mill are still being built with great refinements over the early models.

The ball mill, once a noisy unit with its heavy load of steel balls, has been housed in a sound-proof enclosure and takes its proper place in a quiet smooth-running plant. The gage of the level of the coal in the mill was formerly the ear of the operator but this has been abandoned for a more sensitive and completely automatic device that maintains a constant level of coal.

The vibration of all types of mills has been reduced and all claim and most can prove that a coin will stand on edge on the casing of the mill while it runs under full load. Power requirements have been reduced and wear and maintenance have been lowered.

Air classifiers have been improved and the fineness of pulverization can be adjusted and maintained as required. The degree of pulverization of coal has not been varied greatly but with improved knowledge

OF PROGRESS FUEL UTILIZATION

By RALPH A. SHERMAN
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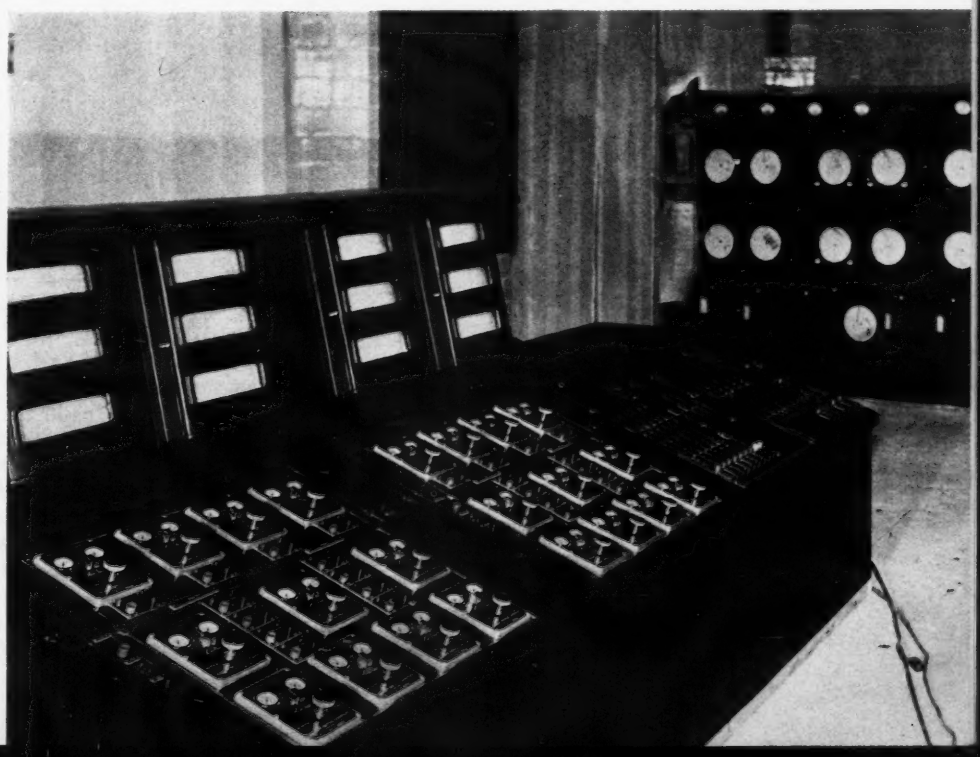
of the grindabilities (a new term in this decade, of which more later) of different coals and of the effect of fineness of pulverization on the performance of different coals the fineness is set to suit the coal and the length of flame travel. It varies from 80 per cent through the 200-mesh screen for anthracites to 60 per cent for western bituminous and sub-bituminous coals.

The rates of heat liberation have been increased somewhat and furnaces have been designed for rates of above 50,000 B.t.u. per cu. ft., per hr. and as high as 90,000 in the primary furnace of a two-stage furnace but designs for rates of 20,000 and lower are still common. The higher rates are used in the slag-tap furnace which was first used only in the late twenties but rapidly came into wide acceptance in the thirties. The merits of the slag-tap furnace, the elimination of difficulties with accumulation of slag on the floor or below the slag screen with consequent difficulty in removal, and increase in the amount of ash removed through the ash pit and a reduction in the amount of fly ash, hotter furnaces and improved heat absorption by the furnace heat-absorbing surface as well as a reduction in carbon loss, are generally recognized. The early furnaces gave difficulty in retaining the slag in the bottom without occasional leakage and in pushing out of furnace walls as it froze when the boiler came off. Many refractory bottoms were tried but the logical solution came early in the decade with the installation of a water-cooled floor covered with some refractory; soon the slag makes its own floor.

The early practice of storage of the slag in the furnace with intermittent tapping at 12 to 24-hr. intervals gave way to continuous tapping into a moving stream of water and gave lessened difficulties and labor. Slag-tap furnaces require hot furnaces with the highest temperatures near the slag floor. Two methods, one by down-shot burners which impinge on the slag and the other where the flame sweeps across the slag floor, such as the burners in the four corners



The main combustion control board at the Ottawa St. station at Lansing, Mich., where the technique of burning fuel has reached a high state of development

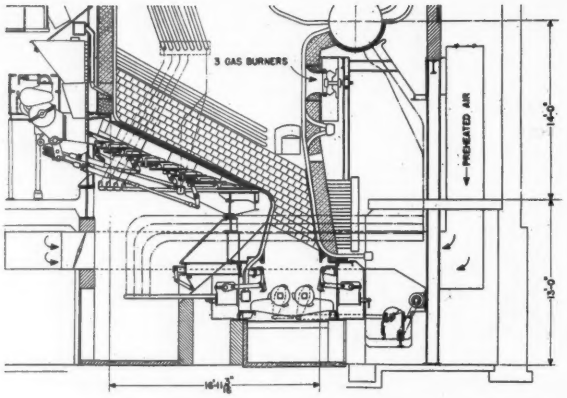


Fig. 1. The possibilities of the combination firing of natural gas and coal with a water-cooled stoker installed in a furnace with water-cooled back wall are shown in this installation in the municipal plant at Austin, Minn. Coal with an ash softening temperature of 1900 to 2100 deg. F. is used

which fire tangentially to a circle in the center of the furnace, are used successfully.

Furnaces hotter than the fusion point of the ash mean molten slag particles in either the dry bottom or wet-bottom furnace. When these impinge on boiler tubes, they stick and the coating insulates the tube against heat absorption and may bridge across the tubes in boiler passes to obstruct the flow of gases. Control of fouling of boiler tubes with slag and ash requires a knowledge of heat transfer from flames to control the temperatures and a knowledge of the fusion and viscosity characteristics of the ash to establish the temperatures required. Progress is being made to establish this knowledge but the elimination of boiler-tube fouling remains a problem for the next decade.

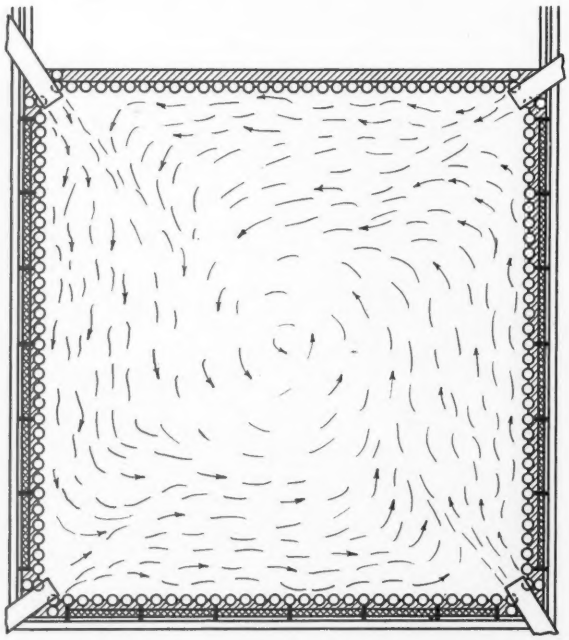


Fig. 2. General arrangement of burners in a typical tangentially fired pulverized fuel furnace, showing how turbulence is secured by this method of firing

Multiple-Retort Underfeed Stokers

Pushed by the competition of pulverized coal, the multiple-retort underfeed stoker has been improved to keep pace with the demands of users for high rates of burning, the use of preheated air, and a versatility in the selection of coal. Coals, whose ash clinkers severely, have been a problem for the high-duty underfeed stoker and the lower the fusion temperature of the ash, the lower the preheat temperature that could be carried without the production of a sheet clinker that stopped the tuyeres and resulted in burned stoker iron. The water-cooled stoker, in which boiler tubes are carried down the tuyere stacks to absorb heat from the fuel bed and prevent the fusion of the ash, was first developed at the Cedar Rapids plant of the Iowa Electric Light and Power in 1934. A substantial number are now operating, and have permitted a wider selection of coals, have given increased reliability and have reduced stoker maintenance.

Another difficulty with large stokers that has been seriously attacked in the past ten years is the non-uniformity of rate of burning over the grate area. With uniform air pressure under the entire grate and with most of the resistance to air flow in the fuel bed, thin spots in the fuel bed got most of the air and high rates of burning, high temperatures, fused ash, and burned iron resulted. Zoning of air to the stoker with automatic control of its flow and tuyeres with

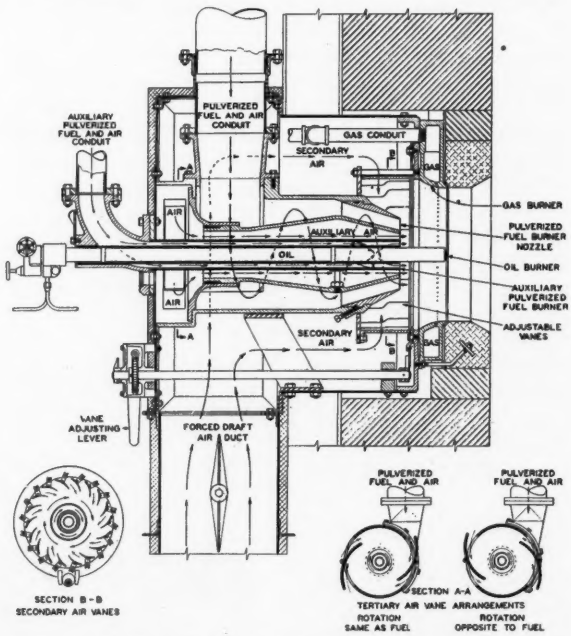


Fig. 3. Typical of combination burners developed because of the availability of various fuels of different plants is this designed to burn oil, gas, or pulverized coal, singly or in combination

venturi nozzles that give self-limiting characteristics to the air flow, as in the Noblo tuyere, have increased the uniformity of air distribution and have permitted the maintenance of higher average rates of burning without excessive local rates.

Greater agitation of the fuel bed to break up masses of coke over the retorts and avoid narrow lanes of intense burning has been attained by the design of pusher mechanisms as in the Link-Grate stoker. Con-

tinuous discharge of the ash has been accomplished with the adoption of rear water walls.

Single and Double Retort Stokers

The fundamental principles of the single and double retort underfeed stokers have not changed in the past ten years but methods of selling have to a considerable degree. In addition to the manufacturers of multiple-retort stokers, most of whom also make the smaller models, very many of the builders of residential stokers whose number and sales have increased so remarkably recently also build stokers that will fire up to 1200 lb. of coal per hour. They have been aggressive in their sales and as many replace hand firing in heating, process steam, and small power boilers, the general level of efficiency in the use of coal has been greatly increased.

Many of these are of the ram-feed type but many use the screw feed and some a combination of screw feed and rams or pusher blocks in the lower part of the retort to distribute the coal. The use of a prolonged screw feed permits the stokers to be fed from a bin and a great saving in labor is gained. Automatic air volume controls, simple devices that maintain a constant supply of air over wide variations in fuel bed resistance, pressure and temperature controllers, and refueling devices bring the small plant many of the advantages of large installations in essentially packaged units at low cost.

Spreader Stokers

Spreader stokers, which distributed coal over the grate from above by mechanical means, were developed before 1930 but their great increase in acceptance is a feature of the past ten-year period. The modification known as the pneumatic spreader stoker, in which the coal is carried in an air stream for distribution over the grate, was developed and marketed during the decade; it, too, has gained wide acceptance.

Simple in design but with ingenious methods for uniform distribution of the coal over the entire flat grate, which may be fixed or dumping, these stokers are not sensitive to the type of coal. The fuel bed is thin and with the coking characteristics modified by projection through the flame, the matting of the coal is largely avoided. Without agitation and mixing of the ash, even low-fusion coals are burned without serious clinkering difficulties. With only a small storage of fuel in the bed and with the burning of a considerable part of the fuel in suspension the stokers have a marked flexibility of operation and ability to handle rapidly changing loads.

These stokers are also versatile in the size of coal that they will handle. Normal slack and screenings such as 0x1½ in. or ¼ or ⅜-in. slack can be fired. Large quantities of the latter sizes have become available in recent years in the preparation of special sizes of coal for the residential stoker. This coal is often of high quality but is undesirable for underfeed stokers because of its small size and its disposal is often a source of difficulty to the producer. The advent of the spreader stoker has benefitted both the user and the producer.

The thin fuel beds, the small size of the coal, and the projection of the coal across the moving stream of gases where a part of it is burned usually means that coal may be burned with little difficulty from black smoke. The same factors are, however, conducive to the emission of flyash and manufacturers recommend the installation of fly ash traps and collectors wherever its discharge from the stack might constitute a nuisance.

Oil and Gas

Burners for oil and gas have changed little in the last ten years but their general use under boilers has markedly increased. With increasing markets for gasoline, more fuel oil has been available and its low price has made it an attractive fuel in markets where coal was formerly the predominant fuel. The extension of trunk lines for natural gas from the Texas fields to cities in the middle west, though primarily for

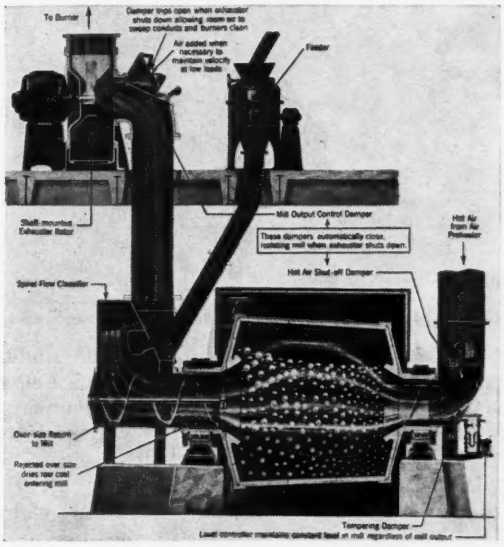


Fig. 4. Outstanding features of this ball-mill pulverizer are the enclosure to eliminate the noise and the automatic level controller to keep a constant level of coal in the mill

domestic uses, has made available gas at low prices for industrial uses in order to load the line.

Many conversions from coal to oil or gas have been made, some by removal of coal burning equipment, others by installation of burners to permit quick changeover or often for simultaneous burning of two fuels. Blast-furnace gas and coke-oven gas have also been available to a few industrial and utility plants. Pulverized coal burners are usually readily convertible to oil or gas and many installations have been made in which any one of the three fuels can be burned.

The application of water cooling to the underfeed stoker has also made possible oil or gas firing with coal firing either separately or in combination. The water tubes on the tuyeres prevent damage to the iron of the stoker when the fluid fuels are being burned.

Refractories

The tendency to avoid the failure of refractories by doing away with them started in the twenties and has continued at an even greater rate in the thirties. Closely spaced tubes in front of refractory walls, fin-tube water walls, and tubes faced with refractory or

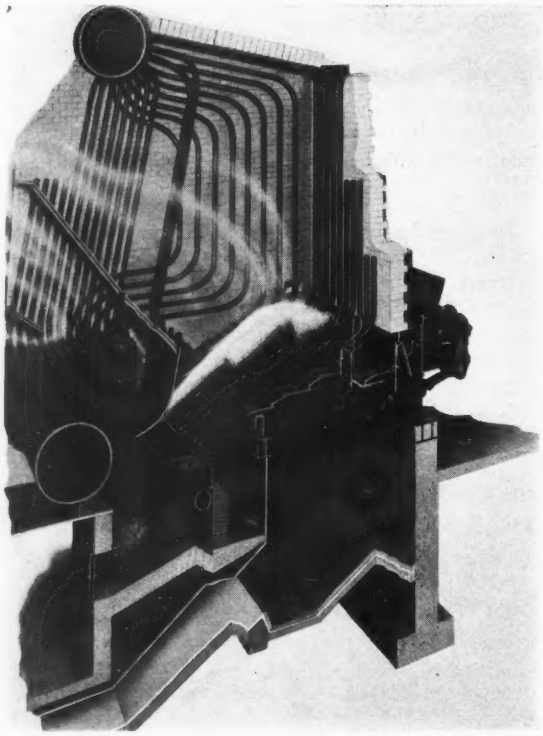


Fig. 5. A continuous ash discharge, water-cooled underfeed stoker

metal blocks have continued in use. The stud-tube refractory walls, made up of tubes onto which closely-spaced short studs are welded to form a support for a rammed plastic refractory, usually chrome because of its slag resistance, is an important development of the decade.

Even without refractories in the furnaces of large boilers, boiler-furnace fire brick still constitute a large fraction of the output of the refractories industry. For backing up brick, for the walls above the furnace, and in smaller furnaces, boilers are still large users of refractories. The manufacturers have brought out no radically different types of refractories in the past ten years but have continued to improve their established products. Lightweight refractories for insulation of high-temperature heat have advanced greatly and have made possible greater economies in heat utilization.

In furnaces with refractory walls, the use of rammed plastic refractories in place of fired shapes has continued to gain favor and their use has extended even to larger boilers.

Problems of the Coal Industry

Faced by increasing competition of oil, gas, and hydroelectric power, still over-expanded in capacity for production which resulted in severe competition within the industry and sales below the cost of production, beset with labor troubles, and from 1933 on loaded with the problem of government regulation of the industry, the producers and distributors of bituminous coal have had a hectic period. These problems were by no means cleared by the end of the ten-year period but many advances have been made that show promise of solution of the difficulties.

In production of coal, the application of mechanical methods of cutting and loading both in underground mining and in stripping has been widespread. The installation of cleaning equipment by which the ash is reduced and, what is often more important, the coal made uniform in quality, and better screening equipment to insure accurate sizing of coals have given the user better coal than ever before. Coal is treated with oil or other materials to render it dustless and thus one of the most common complaints against coal is removed.

Before 1930, only a few of the larger coal producing and selling companies maintained engineers on their staffs. But this period brought the realization that coal could not be sold on price alone but that selling involved also quality and service rendered. Fuel engineers came into demand and today most of the companies have trained and experienced engineers to consult with users and equipment manufacturers on the

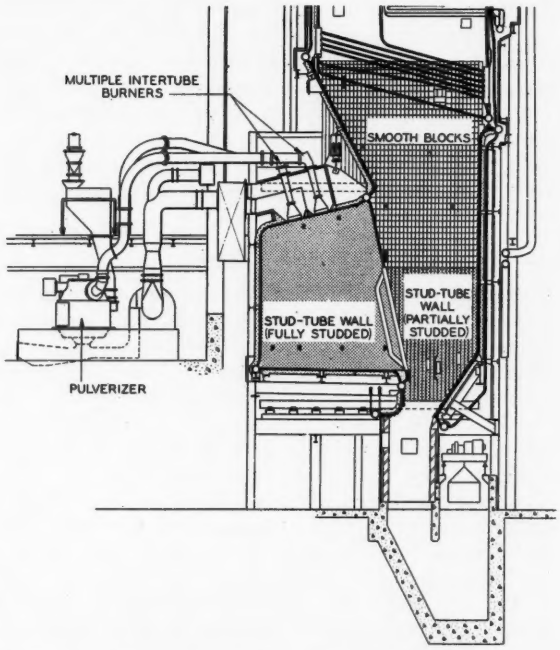


Fig. 6. In this two-stage furnace high-head boiler unit three of which were installed in 1936 in the Springdale, Pa., station of the West Penn Power Co., the molten slag from the floor of the primary furnace flows continuously into a common pit with the slag and ash collected in the cooler secondary furnace. Coal is fired downward toward the slag floor trough multiple intertube burners. The softening temperature of the ash of the coal is 2460 deg. F.

application of the proper coal to the given service. Producers established their own laboratories and availed themselves more frequently of the services of commercial laboratories with the result that more accurate information on the characteristics of coal being shipped is now available.

One of the outstanding accomplishments of the period has been made by the Fuel Engineering Division of Appalachian Coals, Inc., the first coal marketing agency to be established as a result of the Supreme Court decision of 1932. Under the leadership of J. E. Tobey, manager of the division, a series of meetings has been held, first of the fuel engineers of the

member companies alone, and later with engineers of the users and equipment manufacturers. As many as 326 engineers have attended these one-day sessions held in Cincinnati, Atlanta, Detroit, and Kalamazoo to hear addresses on the utilization of coal by the leading engineers of the country. No previous effort has done so much to spread the available knowledge on fuel utilization to those who can put it to work.

An increasing number of conferences on coal and its utilization have been held by the universities—Purdue, Wisconsin, West Virginia, Michigan, Illinois, Washington, St. Louis and Iowa State College. Lehigh University has held two outstanding conferences on the utilization of anthracite. Coal and stoker schools sponsored by producers, retailers, and stoker dealers in Cincinnati and Minneapolis have aided in the dissemination of knowledge of coal utilization in the small boiler and furnace, the field where the need is the greatest. The latter school in May, 1939, drew 506 registrants in a two-day session to break all records for similar efforts.

Technical Societies Active

Because of reduced budgets during the depression, the national fuels meetings so successfully started before 1930 by the A. S. M. E. were halted after the Chicago meeting of 1931. For some years, the sessions were held in conjunction with the annual and semi-annual meetings of the Society. The year 1930 marked the organization of the Coal Division of the A. I. M. E. which devoted its attention primarily at the start to problems of mining and preparation but shortly turned to problems of utilization as well. In 1937, the first joint meeting of the Coal Division of the A. I. M. E. and of the Fuels Division of the A. S. M. E. was held in Pittsburgh, followed in 1938 and 1939 by equally good meetings in Chicago and Columbus. These meetings have brought the engineers of the producers and users together to discuss their common problems and have contributed greatly to their mutual understanding.

Advances Made in Research

The established research agencies on fuel utilization have continued to make their contributions to the knowledge of coal. Although the Bureau of Mines worked for a large part of the decade under a reduced personnel as a result of the Economy Act of 1933. Fieldner and Nicholls and their associates have made great progress. Reports have been issued on the mechanism of the underfeed combustion of coal and on the behavior of coal ash on heating, including the measurement of the viscosity of slags at high temperatures. A comprehensive report on the effect of chemicals on the burning of coal brought to light many of the fallacies of the claims for such treatments but it did not still the hope in the minds of all that someone might discover some remedy for many of the evils attendant upon coal utilization.

The Coal Research Laboratory of Carnegie Institute of Technology started a program of fundamental research on bituminous coal in 1930 which has added many papers to the literature on the chemical constitution of coal and its behavior on heating and during combustion. Much of the information developed from

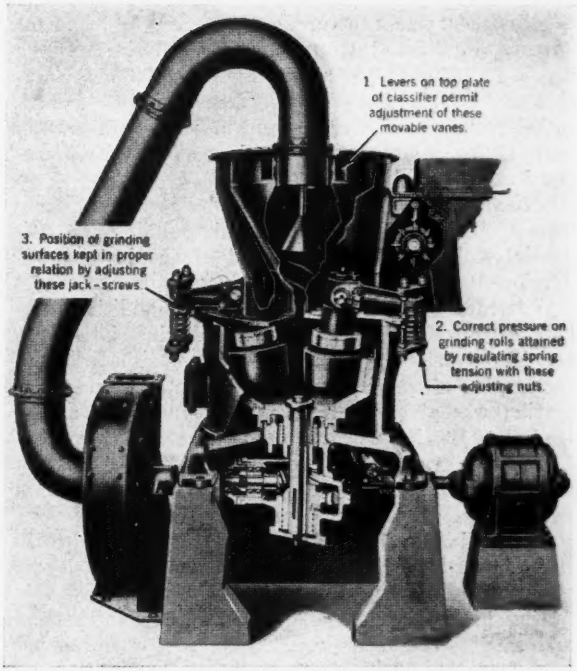

1. Levers on top plate of classifier permit adjustment of these movable vanes.
3. Position of grinding surfaces kept in proper relation by adjusting these jack-screws.
2. Correct pressure on grinding rolls attained by regulating spring tension with these adjusting nuts.

Fig. 7. The provision of three points for adjustment of the fineness of pulverization so that the coal may be neither too coarse with loss in combustible nor too fine with reduced capacity and excessive power is a feature of this new bowl mill

this fundamental research will only see its fruition in engineering practice in the next decade but on investigation of the process of combustion of the fuel beds of multiple-retort stokers at the Hell Gate Station of the Consolidated Edison Co. in 1937-38 will give immediately useful results.

Battelle Memorial Institute, established in Columbus, Ohio, in 1929 for research in fuels, metallurgy, ceramics, and chemistry, made important contributions to the knowledge of the process of combustion of pulverized coal, of radiation from pulverized coal and natural gas flames, and of the tempering of coal.

The bituminous coal industry, realizing that it could not leave the advances in coal utilization entirely

Fig. 8. Manual handling of coal is eliminated even for the small plant when bin-feed stokers are installed as in this battery of five installed at Selfridge Field, Detroit, Michigan

to equipment manufacturers, users, and government bureaus, established Bituminous Coal Research, Inc., which, in 1935, started a program of research. Valuable new information on the hydrogenation of coal resulted from research carried on at The Pennsylvania State College. Other work was done at Battelle Memorial Institute.

Much of the effort at Battelle was devoted to problems of the characteristics of coals suitable for residential stokers but a great deal of the information developed even in this work is equally applicable to coal burned on larger equipment. In addition, surveys were made of the use of coal on industrial stokers and in pulverized form, and a study was made of the segregation of coal in bunkers. Active help and cooperation was given to the study of fuel beds at the Hell Gate Station with the Coal Research Laboratory. The proper grade of the proper type of oil for dustless treatment of various types of coal was determined in a two-year program of research in which two oil companies and an equipment manufacturer joined with Bituminous Coal Research as Sponsors. A survey of the relation of the volume of combustion space and setting heights of boilers over stokers in the setting and small power class was conducted for the stoker manufacturers, the boiler manufacturers and the coal industry.

The laboratory of the anthracite industry at Primos, Pennsylvania, opened in 1930 under the sponsorship of the Anthracite Institute and later supported by Anthracite Industries, Inc., devoted a considerable part of its attention to industrial utilization of anthracite in addition to its extensive program on domestic uses.

The source of standard methods for testing coal, the American Society for Testing Materials, through Committee D-5 on Coal and Coke approved a number of new standards and revised existing standards. Under its sponsorship, the American Standards Association established standards for the classification of coal by rank and by grade. Methods of sampling were revised, a test for the fineness of pulverized coal was standardized, a method for designation of the size of coal was approved, and a method for determination of the dustiness of solid fuels received tentative approval. Committees were actively at work at the close of 1939 on sampling methods, on the plastic properties of coal, and on ignitibility, the results of which will be of great value to the user of coal.

Prior to 1930, no yardstick was available to determine the ease of pulverization of coal and manufacturers of pulverizers had difficulty in rating mills for capacity and fineness with various coals. Under a subcommittee of Committee D-5 of the A. S. T. M., two methods for determination of this property of coal, termed its grindability, were developed and accepted as tentative standards. They are known as the Hardgrove-Machine method, developed by R. M. Hardgrove and the Ball Mill method, developed by H. F. Yancey. Prediction of the capacity of mills and the power requirements of various coals is now possible when the grindability is known.

A new tool for research in fuel burning was introduced by E. G. Bailey in connection with his paper, "Modern Boiler Furnaces" at the 1938 annual meeting of the A. S. M. E. when he showed colored motion pictures of pulverized-coal flames. Further pictures of similar type but including studies of stoker fuel beds were shown by A. A. Markson and W. H. Dargan of the Consolidated Edison Co. at the 1939 joint fuels meeting in Columbus. This method will undoubtedly be freely used in the future to permit study by slow motion and accelerated motion of phenomena that cannot be observed by the eye on the furnaces themselves.

Outlook for the Next Decade Bright

The editor requested a review and not a prophecy, hence no specific predictions will be made. But the review shows that the progress in fuel utilization in the past decade has been on a firm basis. With such renewed interest in research, the prediction is inevitable that the next ten years will see further steady progress in the development of our knowledge. This will enable the proper application of fuel to equipment, and bring about continued improvement in equipment. The more economical production of heat and power can only result in their expanded use.

Small Plants Combine Elements

Factory built steam generating units, extended growth of automatic control and greatly improved combustion equipment are outstanding features of a ten-year progress.

SPECTACULAR as have been many of the developments in large power plants because of their pioneering aspect and the immensity of the projects, they are not surpassed in total benefits to industry by advancements in technology being applied in a large number of the smaller plants for all types of service.

Except for some rather specialized industrial services, steam pressures and temperatures in smaller plants seldom need to exceed 600 lb. per sq. in and 800 deg. F., materials and equipment for which have become standard and procurable at prices that are within the economic range. Combustion equipment is meeting the needs, in an extremely efficient manner, of the medium and small size plants by the adaptation of equipment some of which went through the experimental stage in large plants and some in extremely small, even residential size, units. Piping materials and fabrication methods so carefully developed for extreme conditions are available for all plants regardless of size. The industrial plant, however, frequently encounters corrosion, erosion and pressure conditions that require special consideration. Steam engines and turbines, internal combustion engines, and hydraulic turbines are all available in standard designs and at costs permitting their use in small plants. The same may be said of all the electrical equipment from the generator to the fuse plug; likewise the instruments.

Very little, in fact, of the equipment necessary for small plants must be specially designed or experimented with in operation; selection as a rule can be

made from catalogs. Each plant, however, must be considered as a special problem as its success as an economic venture depends upon the design of the plant—the layout of the equipment, the selection of the most suitable type and size of equipment for the expected load, the selection of the kind of fuel from those available, provisions for economic operation, together with the thousands of details that must be worked out in coordinating the operation of the main and auxiliary equipment.

Fuel Burning in Small Plants

The greatest expense in the generation of power from steam is for the fuel required. The 60 and 65 per cent boiler and furnace efficiency so common in 1930 should no longer be tolerated when any number of plants have proved that by use of modern furnace equipment and boiler operating methods 80 per cent or better is obtainable. The fuel burning practices in large plants were in many cases considered too expensive in first cost and required expert skill not available in the smaller plant. Then came the development of the domestic stoker, so small in capacity it was not applicable to power boilers but comparatively inexpensive because of mass manufacture. The solution in some plants has been found by incorporating combustion control methods developed largely for the big furnaces into the designs of domestic type stokers built to larger size, with the result that automatic fuel burning equipment is the rule in all new and modernized power plants.

Over size domestic underfeed stokers have been developed with variable speed drives, to take the place of intermittent feeding, and provided with combustion air proportioning devices. The result has been that combustion efficiencies are being attained that compare favorable with those of larger stokers.

During recent years the spreader type stoker has been greatly improved, principally by the application of combustion control methods. They are now being used extensively in institution, office building and many industrial plants. This type of firing, which may be accomplished by either mechanical or pneumatic methods, is applicable to a wide variety of fuels, from lignite to anthracite, as the fuel bed remains porous except when furnace temperatures greatly exceed the fusion temperature of the ash. Considerable of the dust like particles of the coal are burned in suspension which has given rise to some flyash difficulty. Proper firing methods and furnace designs, however, have alleviated this annoyance and the high efficiencies secured are popularizing this type of stoker.

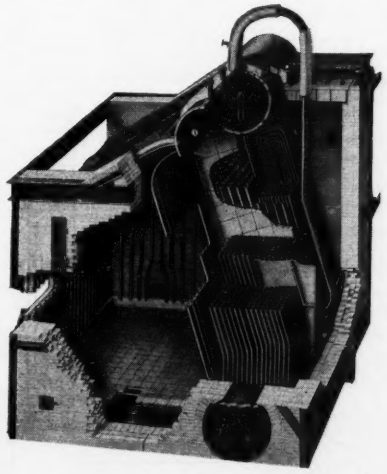


Fig. 1. Integral furnace boiler unit gives small plant high efficiencies

Many small plants offer opportunities for the use of pulverized fuel particularly where oil or gas are at times available at prices competitive with coal, as there are now on the market combination burners and furnaces can be built for the efficient use of any or all of these fuels.

Combined Furnace and Boiler Units

Noteworthy among the developments of the decade applicable to the small as well as large plants is the combined furnace and water tube boiler unit. These units are complete with fuel burning equipment—stoker, pulverized fuel, oil or gas burner—water cooled furnace, economizer, superheater and boiler sections. Air heaters may also be provided, likewise completely or partially automatic combustion control mechanism.

Another combined unit which is designed along the lines of a return tubular boiler is finding application in small plants. This unit, illustrated here, is factory-built and assembled with a built-in oil burner. It comes to the plant mounted on a structural steel base that fits on a concrete foundation. This particular unit develops steam at 80 lb. pressure, has a capacity of 70 hp., combustion is automatically controlled to maintain pressure within 2 lb., and the efficiency is reported to be better than 80 per cent for all loads from 30 per cent up to full rating.

Because of their completeness, these combined units need but few auxiliaries in order to constitute an entire boiler plant and, being designed along standard lines, and many of the smaller units factory built, the efficiencies obtainable are high and the initial costs comparatively low. Space occupied by such units is small compared with older types for similar service and capacity, with the added advantage of considerably increased efficiency. This type of unit is being extensively used in modernization programs where increased capacities are needed in limited quarters as well as in entirely new plants.

Complete Power Generating Unit

While not yet in general use, a development of recent years that is known as the Steamotive offers possibilities for steam and power generation at high efficiency, low attendance costs, economy of space and flexibility of location. The Steamotive was developed as an electric power generating unit for railway locomotive service but several stationary installations have been made. From the introduction of the fuel oil to the delivery of electric current from the generator, the entire unit is automatic. It is, in fact, an entire steam-electric power generating plant, extremely compact and containing features representative of the highest efficiency power generating method in practical use in this country.

The most recent unit of this type upon which information is available is used to drive a Union Pacific

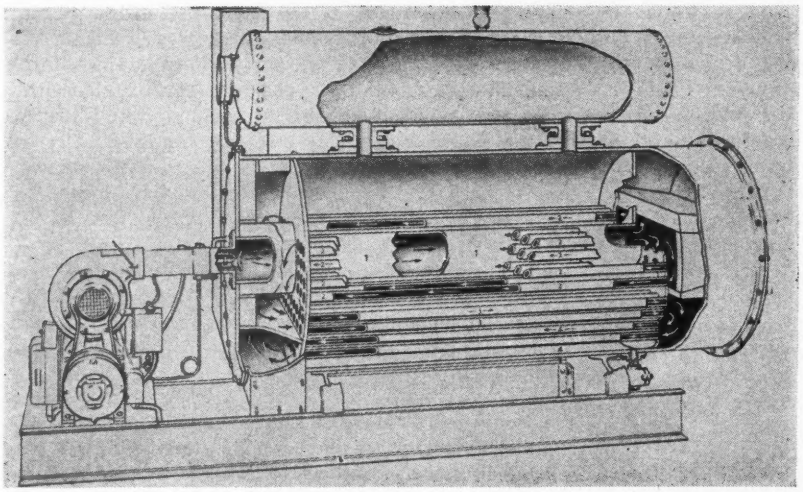


Fig. 2. Diagram of complete boiler unit showing four pass down draft gas travel

railroad train and is completely described in the October and November issues of Mechanical Engineering.

While modifications in proportions and other details from the locomotive design would unquestionably be necessary to adapt a Steamotive unit for stationary service an idea of its dimensions may be had from the following data on this particular unit. The total weight of one unit, fully loaded, is 548,000 lb.; the length over couplers is 90 ft., 10 in.; width over cab is 10 ft.; height over-all is 15 ft., ¾ in.; the main steam pressure is 1500 lb. per sq. in.; steam temperature is 920 deg. F.; rated power output for traction is 2500 hp.; and the output for train heating steam is 3000 lb. per hr.

Diesel engines have found a distinct place in power plants of small and medium size where the demand for heat does not exceed that which can be secured from the exhaust gases and jacket water, and are definitely replacing many of the older steam driven power units. The improvements that have taken place in recent years have made this type of unit much more reliable than in former years and reduced the operating costs to a considerable degree. This has been treated in another article in this issue but the possibilities of the Diesel engine should not be overlooked when considering power demands on small and medium size plants. A number of completely automatic Diesel units and plants are now in operation, a feature which is highly desirable for standby service or where loads are likely to be intermittent.

Occasionally plant owners have so equipped their plants that constant attendance is not necessary. While this practice has been used for many years in the operation of electric substations, motor driven pumping plants and even small hydroelectric generating stations, the first completely unattended steam turbine unit to receive public attention was put into operation about six years ago to serve an industrial establishment. The turbine is a 1000-kw. unit designed for either back pressure or condensing service. The presence of inflammable gases in the buildings accommodating the various pumps and compressors, made the installation of the turbo-generator unit in their immediate vicinity entirely out of the question and it was therefore decided to provide suitable housing by the erection of a small building some 200 ft. away from the process area which was considered quite safe.

In steam plants where electric generating units of 1000 kw. capacity or less are most suitable, many designers favor the uniflow type of reciprocating engine. These engines are economical to operate and offer the flexibility of application so frequently needed in plants where low-pressure steam is required. Units are available which may be operated non-condensing or condensing with provisions for changing from one to the other automatically to suit steam requirements. They are also adaptable for variable back pressure up to as high as 30 lb. During recent years the designs have followed the modern trends toward the use of special metals for specific purposes, improved lubricating methods and more exacting and flexible controls.

Small and medium size power plants are in that favored economic position where the equipment installed is manufactured along standard lines in quantities that make prices favorable.

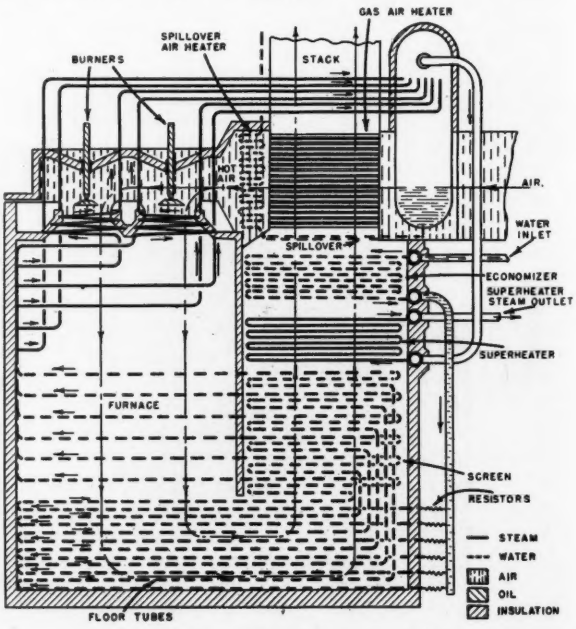


Fig. 3. Cross section of steamotive boiler

In the face of increasing construction costs, engineers have advanced power generation practice so that when consideration is given to superior equipment now available lower relative initial costs are possible today than in 1930.

Trend of Steam Power Station Costs

By JAMES E. BURKROSS
Mechanical Engineer
Sargent & Lundy, Inc.

OF INTEREST to executives and their engineers is the cost of installing equipment for the production of power. There probably is no question in the general belief that the cost of materials, equipment and labor has shown a decided increase the last decade, but the developments through study and research have done much to reduce such cost, all as hereinafter described.

As a starting point, let us consider the effect upon a power station of which the cost is known, and apply to these costs the various price index values as reported by different trade journals and authorities, covering in particular material and labor which directly make up a large part of the structure's account. The equipment index values are those furnished by manufacturers of the different kinds of machinery.

The station under consideration, which was of the condensing type, incurred construction costs which were allocated as follows: (Land not included)

(a) Structures 13.7%
(b) Boiler Plant 40.2%
(c) Turbine Plant 37.4%
(d) Electric Plant 8.7%

Various top charges such as interest during construction, engineering, and other administrative expenses have not been included.

The index figures as determined from various sources from 1927 to 1939 are as follows:

	Structure	Boiler Plant	Turbine Plant	Electric Plant
1927	.98	1.02	1.00	1.00
1928	1.01	1.00	1.00	.97
1929	1.00	1.00	1.00	1.03
1930	.99	1.00	1.00	1.04
1931	.89	.94	1.00	1.04
1932	.83	.93	1.02	1 04
1933	.86	.92	1.04	1.06
1934	.94	.95	1.07	1.20
1935	.94	1.02	1.18	1.21
1936	.98	1.07	1.19	1.23
1937	1.08	1.26	1.24	1.32
1938	1.05	1.24	1.24	1.33
1939	1.09	1.30	1.19	1.35

Years 1927, '28 and '29—1.00

Applying the index values to the actual construction cost shows results indicated graphically by Fig. 1. This graph seems to foster the idea that the costs of building power stations today is apparently 20 per cent more than the period from 1927-1929, and is true when consideration is given to equipment and in general, practice remaining unchanged throughout the intervening years.

Let us determine if we can what change the studies of the technical profession and research has upon the advancement of the art and in particular the initial investment costs.

We are fortunate in having costs of similar stations built of practically the same capacity, conceived and designed about 12 years apart. These stations all burn the same kind of coal, which should be considered of paramount importance in attempting to make any comparisons which would be of any value whatsoever.

Applying the trend figures to the costs of these stations, the accompanying graph (Fig. 2) showing two lines, one representing the old plant and the other the modern plant. Obviously the cost of power stations has not advanced proportionately, as all index values seemed to indicate, but have actually declined, and when consideration is given to superior equipment would show a still lower relative initial investment cost.

The reason for this decline in cost per kilowatt becomes manifest when the separate accounts are analyzed as shown graphically in Fig. 3. This chart shows the structures, boiler plant, turbine plant and electric

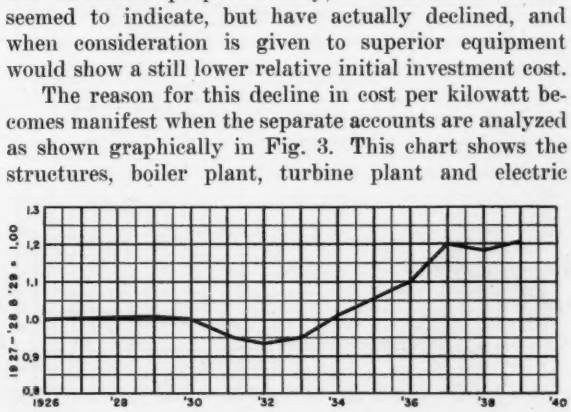


Fig. 1. General price trend, steam power stations weighed percentages

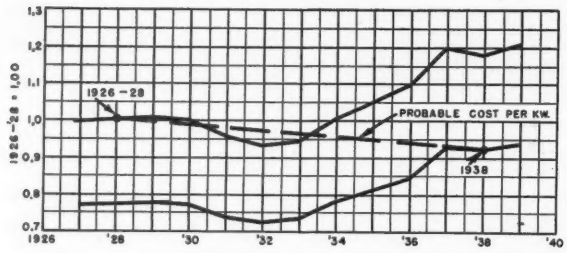


Fig. 2. Relation of cost of power plants of different periods as referred to price index

service trended according to the various index values, and indicates a decided drop in cost per kilowatt of installed capacity with the exception of the turbine plant. Inasmuch as the structures and electrical costs are dependent upon the main equipment, we will consider them with the boiler and turbine.

Apparently the boiler plant shows where the largest item of savings has been effected, representing as it does 40.2 per cent of the total plant cost. It is true that efficiencies have increased during the time, but that slight amount would not change the picture.

The real credit must be given to the following causes, all of them acting together:

1st—The predictions of engineers of having installations consisting of one turbine and one boiler is rapidly coming to the fore. In other words, turbine units which formerly had two or more boilers installed in conjunction therewith, now may be provided with one and not more than two boilers—the saving involved by limiting the number of boilers has considerable effect upon the installed cost of the steam generating equipment, and its allied appurtenances. For instance, the building

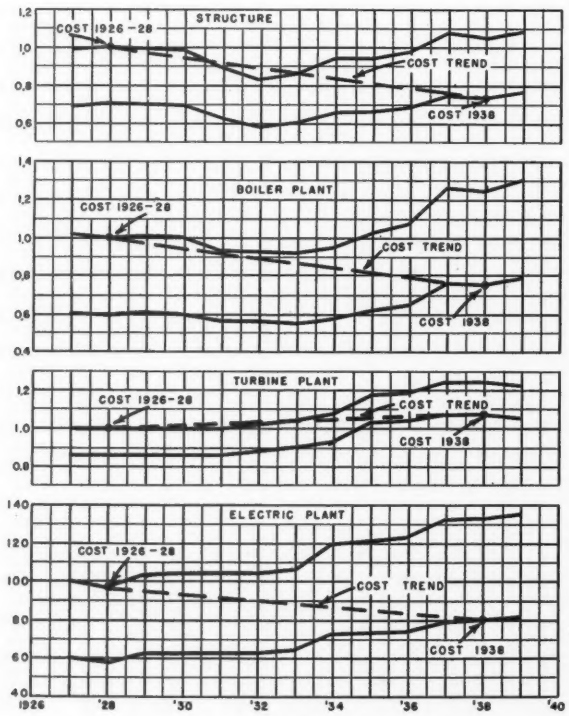


Fig. 3. Costs as compared with index values

and piping costs will materially decline with the number of boilers. Galleries and platforms likewise in general drop in proportion to the number of aisles between and around boilers. Electrically, the initial cost of conduit and cable for one motor double in size to another is but a small increase. Likewise, in small plants both forced and induced draft fans may have a common motor drive.

2nd—The work done by the pressure parts of the boilers has been materially increased. This is of importance because the pressure parts represent a considerable part of the boiler cost. Figure 4 shows in graphic form this increase. The graph shows an increase in work done amounting to approximately 40 per cent. This is quite remarkable and reflects the designer's ingenuity in obtaining the maximum amount of work from a given surface. There is no question that the development in furnace design has been responsible for the improvement.

3rd—Less heating surface installed per kilowatt of installed capacity. To illustrate this point Fig. 5 has been prepared. The progress in design of boilers per-

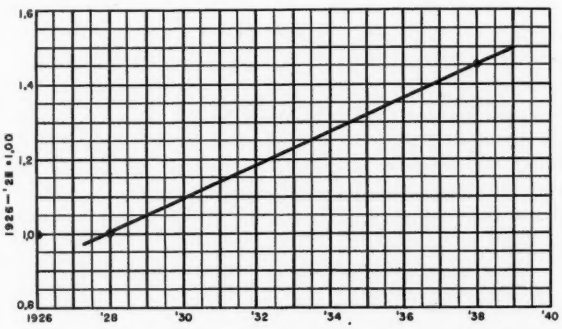


Fig. 4. Heat absorbed by high-pressure surfaces of boilers

mitting proper cleaning of soot from tubes, the treatment of feedwater, and improved furnace design has made a marked change upon what was thought in past years to be the proper amount of surface to be installed with the initial installations. In view of these improved conditions, boiler reliability is more and more being placed on a par with the turbine unit, and reserve boilers are not now being installed to the same extent, particularly on interconnected systems.

The turbine plant, embracing as it does the turbine, generator, foundation, and condensing system, does not show such a wide divergence of cost as the boiler plant. It is interesting, however, to note the effect of the designers upon the work done by the condenser surface. Figure 6 has been prepared to show the results of this analysis. The regenerative feed heating cycle has also reduced the duty on the condensers materially.

Another item causing a considerable saving in foundation and building space is the universal use of higher speeds in the prime movers.

Savings have also resulted from the use of welding, practically all pipe lines being so treated. With the advent of higher pressures steam and water velocities have likewise been increased above the velocities prevalent a decade ago.

As a result of the changes which occurred in the boiler plant, the cost of the building work has been con-

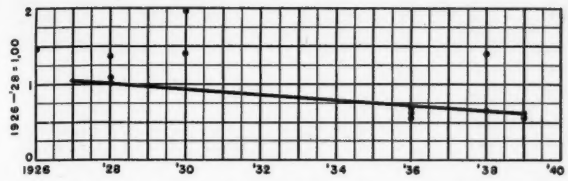


Fig. 5. Square feet of high-pressure surface installed per kilowatt of capacity

siderably reduced. For instance, the reduction in number of units has reduced the number of aisles, the increase in heat absorption and decrease in installed square feet per kilowatt has materially reduced the building volume. Of course, it is true that the steam generating capacity has been concentrated in fewer units, causing heavier loads, the influence of which upon some parts of the building construction is comparatively small. For instance, doubling the load on a foundation caisson may increase its costs only 30 per cent.

For the same reasons, the costs of electrical service for auxiliary power have been considerably reduced from what would have resulted from the increased costs. For instance, the cost of certain types of switches have increased over 50 per cent.

The electric plant likewise has been susceptible to a considerable reduction in cost due to improvements in design. For instance, power for the auxiliaries has been supplied direct from the generator leads, thereby eliminating expensive switching; lower voltage motors have been installed which reduces the cost of motors and switching. More equipment has been placed outdoors, saving corresponding building space.

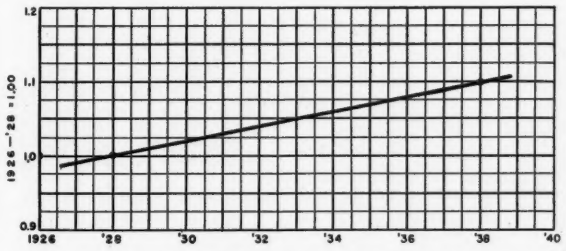


Fig. 6. Work done by condenser surface

From the data determined from the above discussion, Fig. 7 has been prepared to show the trend of power station costs for the period indicated. It must be appreciated that a large part of this analysis is purely academic, but the prices for which power stations have been recently built seem to bear out the conclusions indicated by this graph.

While the price trends have indicated a definite increase, the premises probably are not exactly similar, for instance, equipment sold perhaps, to operate at 600 lb., 750 deg. F., a decade ago has in some cases been found sadly lacking and replacements made after a few years with superior metals not known or used when the equipment was sold. This is true in all equipment whether it be a turbine, pump or boiler. Obviously, then, the equipment sold today, embodying the latest developments, will no doubt last longer with less maintenance cost than its older relative, even though the same work was and is performed by each. This in a sense shows the danger of using price trends as a determinative of relative values.

It should be noted that the dip shown in installation costs in 1932-1934 is not as pronounced as would be expected. It is quite possible, and in some instances true, prices paid for labor, material and equipment was considerably below the trend figures. This influence, however, was upon such a small percentage of work as referred to the normal requirements of the industry as a whole that any reference to the cost of such work is of no value.

Heretofore our discussion has been concerned with the condensing plants. The development of new materials permitting the use of higher pressures and temperatures has placed in the hands of the engineer an instrument of great importance from which has developed the superposed installations. These installations have a three-fold purpose, first, the economics effected by the use of the higher pressures and temperatures;

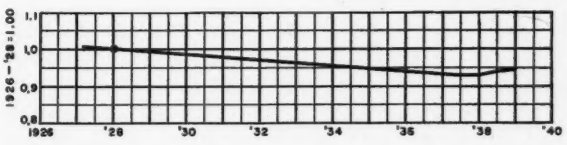


Fig. 7. Trend in power station costs as referred to kilowatt capacity

second, the increase in capacity obtained by the superposed turbine; and third, the longer life given the old generating equipment which would otherwise be obsolete within a relatively short time.

When the subject of cost is considered a considerably different picture is presented when compared with the condensing plant. In the superposed plants investigated, it was noted the boilers and appurtenances represented from 50 to 60 per cent of the total cost of the installation.

Figure 8 has been prepared to show the trend in high-pressure boiler costs as covered by the recent active years. This increase presumably can be explained by the increased costs of materials and labor on one hand, and of the discovery by the manufacturers that each installation being different took this type of boiler out of the production class, and placed it in a special class carrying continuous development charges. It is to be hoped that these prices stabilize, so that more accurate economic studies can be made. This is particularly true with reference to superposed installations, as the boiler capacity requirements are usually about three times that required for the same capacity in a condensing unit.

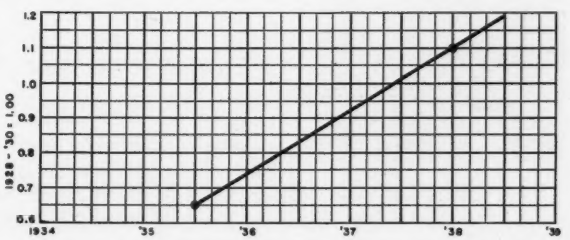
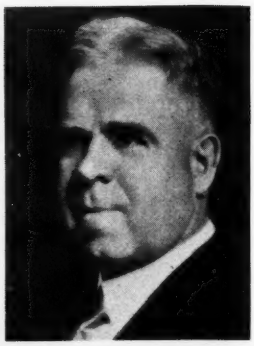


Fig. 8. High-pressure 1200 lb. boiler costs as covered by recent active years

THE AUTHORS—

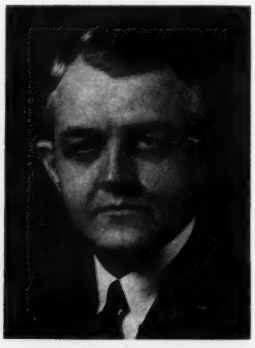
in the order of their appearance

R. C. ROE, president of Burns & Roe, Inc., Engineering Consultants, New York City, has earned an enviable position in the power industry through the design of a score or more of outstanding utility and industrial power plants including Bremo, South Amboy, Ottawa St. and Ruppert's Brewery and for his research and investigations on cycles and high pressures and temperatures up to 2700 lb. and 1000 deg. F. Previous to the formation of the Burns & Roe partnership in 1932 he was vice president of Harry Reid & Co., Inc.; chief designing engineer for the Electric Management & Engineering Corp.; and operating supervisor and design consultant for the General Engineering & Management Corp.



A. E. WHITE, Professor of Metallurgical Engineering, and Director, Department of Engineering Research, University of Michigan, Ann Arbor, Mich., graduated from Brown University, 1907, and studied at Harvard, and was later in charge of research on blast-furnace by-products, ores, etc., for Jones & Laughlin Steel Co. In 1911 he became instructor at the University of Michigan, assistant professor 1913-1917 and has held his present positions since 1919. From 1917 to 1919 he served in the Ordnance Department, U. S. A. as head of the Metallurgical Branch of both the Inspection Div. and Technical Staff. He is a past president of the A.S.T.M. and was the first president of the A.S.M.

J. J. KANTER, research metallurgist in the Crane Research and Development laboratories, attended Armour Institute of Technology and the University of Chicago, obtaining a degree from the latter. He has been engaged in research relative to the application of materials to high temperature service for a number of years, and in 1929, jointly with the late Dr. L. W. Spring, was awarded the Dudley medal by the A.S.T.M. for outstanding investigations concerning the creep of steel. He is a member of and active on many committees of the A.S.M., A.I.M.M.E., A.S.T.M., A.S.M.E. and the A.F.A.



RALPH A. SHERMAN for the past decade has been supervisor of fuels research at Battelle Memorial Institute, Columbus, O., where he has directed research on solid fuels, pulverized coal, oil and gas. For twelve years previous to joining Battelle, Mr. Sherman was fuel engineer with the United States Bureau of Mines, a period interrupted by service in France with the Signal Corps of the A.E.F. He is a graduate of The University of Iowa, where he majored in chemistry and fuel engineering. He has long been active in technical societies' committee work.

F. G. STRAUB, special research associate professor in chemical engineering at the University of Illinois, received his B.S. degree from Illinois in 1920; became research fellow at Mellon Institute; entered the employ of the Semet Solvay Co., Syracuse, N. Y., and later receiving his M.S. and a professional degree of Metallurgical Engineering from Pennsylvania State College. Since 1924 he has been conducting research at the University for the Utilities Research Commission of Chicago particularly on such problems as embrittlement, scale, corrosion and turbine blade deposits.

JAMES E. BURKROSS, mechanical engineer with Sargent and Lundy, Inc., Engineers, Chicago, Ill. He attended Lewis Institute and the Armour Institute of Technology in Chicago. He has been with Sargent & Lundy since 1906 and is now in charge of appraisal, estimates and costs. The history of this company extending back nearly half a century to the period of the reciprocating engine, covers the full development of the turbine and the modern power station and forms a background from which Mr. Burkross can speak of power station cost trends with authority.

The PRACTICAL ENGINEER *and* ELECTRICIAN

R. H. MORRIS, EDITOR

A New Year and a Troubled World

A Happy and Prosperous New Year to you all and may 1940 go down in history as the year that wrote "Finis" to the depression in order to start a new volume on reasonable prosperity devoid of the violent swings of the last decade. With three major, and apparently unrelated, wars going on in Eurasia such a greeting will sound ironical to our old world friends but domestic conditions are such that it has been many years since a New Year's greeting has had a better chance of coming true.

For myself, the New Year brings some misgivings and a definite fear that last year's ready agreement to the rotation of editors was a mistake. Harking back to his Navy days, Andy Bill literally launched the Practical Engineer single handed. His sincerity and enthusiasm backed by your immediate support left no question but that it fills a long felt need and that it is your magazine.

During the ensuing months this support grew by leaps and bounds and we look forward to the time when an increase in the number of pages will be warranted. As a start in this direction we have altered the name slightly so as to make the Practical Electrician feel more at home. Both groups have a lot in common, so much in fact that a considerable portion of the space in the Practical Engineer has been devoted to electrical problems. The change in name will, therefore, mean no decrease in the space devoted to other fields but will for the first time give the electrician a magazine which he can feel is his own.

This has been our aim from the first, it is your magazine, you determine what goes in it, you write the articles and you take out in proportion to the effort you put in. Bring on your knotty operation and maintenance problems, we have over 18,000 experts just raring to go!

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A Section of Power Plant Engineering Devoted to
PLANT OPERATION AND MAINTENANCE

Technical Publishing Company
53 West Jackson Blvd., Chicago, Ill.

While the tradition, training and practical experience of the marine engineer has influenced stationary power practice the industrial engineer of today must have a versatility and range of practical experience that demand an entirely different standard of measurement. Lacking glamour, romance and adventure it is just as exacting, even more essential to civilization and demands the same close coordination with fellow workers.

Even Engineers are Human

FOR SOME REASON easier to understand than explain, the sea has an almost universal appeal impressed from infancy by fact and fiction. It is as real to the youth who has seen white caps only in fancy on the prairies of the middle west as it is to the one brought up on the coast with generations of seafaring tradition behind him. In fact the realism may be greater for the commonplace is hidden by a mantle of glamour and romance. This makes it easier to reconcile the practical necessity for making a living with the human yearning for adventure and a natural curiosity as to what lies over the horizon, yet avoid commitments to a humdrum existence of monotony.

Nor is the reasoning altogether at fault. Routine life on shipboard may be monotonous, yet is a monotony of rigid discipline, leavened with personal and collective responsibility and broken by frequent periods of unrestrained freedom. Nowhere except in the solitary desert and mountains of the west is nature more impressive and man less significant. Yet there is an exhilaration in the endless trackless wastes of the sea, a feeling that it is good to be alive, to be a part of the steady rhythmic vibration of the hull pounding out Man's answer to the challenge. In the magnanimity of the occasion even the deck officers and crew seem to have a place. There may even be a twinge of conscience over the complacency with which mysterious oil and grease spots are viewed when they appear on clean gratings at just the right point to soil natty uniforms when they intrude with curious passengers.

In spite of being a single link in the human chain that puts life, power and personality in a mass of inanimate metal, every man's job is his own responsibility as long as he proves capable of handling it without endangering the common safety or work of others. This individual responsibility is better understood and appreciated after standing a few extra watches to nurse along a hot bearing, for the price of carelessness is overtime but no money. Square pegs are soon shaken out of round holes and those that remain like the sea, like engineering, or, are sufficiently adaptable and satisfied to prefer it to the vagaries of the unknown occupations.

The Unity of Purpose

Day after day there is the same common problem, the same responsibility, the same group, the desire of the young men for a ticket, the urge of the older ones to climb a step higher. For unity there is the pride in a common profession, loyalty to associates and tradition. In retrospect the Queen's birthday in Amsterdam, a misunderstanding with a local gendarme, or a slight, but rough, difference of opinion with a rival nationality over nothing in particular, serves all the practical purposes of a major war but with the bloodshed and suffering considerably more localized.

Even weeks on the beach are lightened by simple tales of questionable adventure in all parts of the world, tales of no particular importance yet sufficient to keep alive the spirit of travel. Each day brings new dreams that the next voyage out will be to some unknown port—a sailor's paradise where good U. S. money opens all doors even to rough Americans.

Constant association of men with the same common interest, the same problems and, to a large extent, the same background, is conducive to training good engineers. There is experience gleaned from the seven seas and the tradition of duty in a school where one serious mistake means the end of a career. The chief, supreme in his own domain, may be executive, paid for what he knows and not what he does. But he knows—for he has climbed up step by step and as a capable first assistant had to learn how to handle men as well as machines.

He may be thick-headed, insist on doing things the hard way but it is the way practical experience has taught him it can be done and he cannot take chances—he must know. This probably accounts for the positive way marine engineers talk even on matters as trivial as the following. Once while taking over the watch I found Mr. Joyce, then senior engineer of the I.M.M. and chief of the old Kroonland, long since sold for junk, squatting on his heels in the for'd fire room intently watching the drain valve from one of the fuel oil tanks.

He asked me to keep an eye on it and left. Not knowing that he had added water to loosen the sludge on the bottom, I kept a close eye on it for several hours and when he finally came around again remarked that there was certainly a lot of water in the tank. His retort was typical, "You're dombed right there was a lot of water there, Mr. Morris, I put it there myself, I KNOW." What he used to say about the promiscuous use of the bilges was just as positive and much more colorful, although perhaps irrelevant here.

Everyone Learns

Having worked off and on for several years in the shipyards where men did what they were paid for and no more, the interest in detail and volunteer help on shipboard with even the simplest job of changing a gage glass or packing a pump was always a source of wonder to me. Days later a strange wiper or oiler might waylay me to ask why it had been done this way instead of this way. Perhaps they would have evinced the same interest in the bottle technique of the woolly Mr. Glencannon on the Inchcliff Castle.

However, the necessity for knowing how to handle any difficulty that may arise, promptly and without a mistake, gradually builds up a conscious or unconscious resentment against innovations especially evident in the older men brought up in the era of triple expansion engines. Centrifugal pumps

and turbines were, and probably still are, the Devil's own invention. Due to youthful, inexperience, I overlooked the advantages of the sea with three square meals and a place to sleep, joined the Signal Corp and so missed the trials and tribulations of the 90 da. merchant fleet. After the war, however, I was working on a pump trouble gang and one day went over to Hoboken with the foreman to look over a centrifugal hotwell pump reported defective on a ship that has just docked.

We escaped physical violence only because the chief had passed the stage where he could do anything but bellow and shake. The sight of the pump sent shivers through the good Scotsman and he left, vowing he'd not leave port until he had a good old steam pump. The pump itself was all right but a valve in the vent line back to the condenser to prevent steam binding was jammed shut with the stem twisted so badly it broke when opened.

The Chief is Disappointed

Apparently his antipathy for centrifugal hotwell pumps was of long standing. He had taken over just before sailing time, headed straight for the pump, closed the valve and left orders that it was not to be opened under any circumstances. It wasn't, and judging from the erratic reports on vacuum the condensate level ranged periodically from the pump suction up to the neck of the condenser. The chief probably died of apoplexy later for he sailed the next week without his steam pump.

There is no question, however, that marine engineers have played an important part in the power plant ashore as well as afloat. Probably no one played a greater role in this than the late John Anderson of Milwaukee by the practical development of pulverized coal. The engineers' caps at Lakeside Station are momentos of his seafaring days.

During the early days of Lakeside, I was working at a smelter in the southwest where they had been firing pulverized coal in reverberatory furnaces since about 1916. I had considerable correspondence with him about coals, mill capacities and maintenance and one day while in Milwaukee asked him how he became interested in pulverized coal. "One day about 1900, I went to Coney Island with friends," he said and added quickly for he was always proud of his early experience at sea, "all of us marine engineers—to see a demonstration of pulverized coal firing under an H.r.t. boiler. It looked good to me and I never forgot it."

After almost 20 yr. dreaming of making pulverized coal practical he had to suceed. Under the circumstances it is easy to understand why what looked like smoke to other engineers was "just a little haze" to him.

On the other hand, Harvey Cushing of Buffalo, who played an equally important part in forcing the direct fired system, is by early training an electrical engineer, so that after all perhaps it is the man himself and his ability to seize opportunities, not his early training, that is really important.

Not All Restless Souls Go To Sea

Certainly the sea is not the only way to satisfy that feeling of restlessness. Wanderlust, an inherent and perfectly normal instinct in young men, is, however, frowned upon by the older and more substantial citizenry as an indication of a shiftless, unreliable, ne'er-do-well character, well summed up by the old proverb, "A Rolling Stone Gathers No Moss." While it may not have contributed to the stability of labor the old journeyman system, if taken literally, lent a mantle of respectability to the search for greater opportunity just over the hill and did a lot for one's peace of mind. At the same time it was possible to crowd a lot of experience into a few years and leave something to live on, and by, after settling down to a more conventional existence.

Be that as it may, the decline of the apprentice system and the severity of the depression made matters somewhat complicated. A young man with a job, probably burdened with partial or entire responsibility for supporting other members of the family, had little choice. He could stay and like it; he could quit and look to, but not necessarily get, relief; or he could quit and be a bum. Relief, while often necessary, is not something which the average American looks forward to with relish. Bumming does have a glitter which soon wears off for a young man who likes to eat regularly. At least I found it that way in the de luxe days when a uniform or army discharge was almost as good as a president's pass if one were not too exacting about company or railroad service.

Of recent months the situation has changed materially, better business and new plants are opening new jobs, and there is considerable change. For the first time in years, I have heard young operating engineers openly expressing an interest in change. The excuse, "nothing more to learn here," is not strikingly original or strictly true, but it answers the purpose as well as ever. Not even the most conventional standpatter can blame a man for being ambitious—they may question his judgment and criticize his technique but if he knows his job, does it well and cooperates with his fellow workers, they can only bid him God's speed with the best grace possible.

R. H. Morris.

. . . SHORTS . . .

Serviceable air washer chambers can be made of 18 ga. galvanized sheet iron braced on the outside with 1½ in. steel angles. Joints and rivet heads should be soldered to prevent corrosion and connections should be fitted with rubber gaskets. Hinged inspection doors should be provided for inspection and maintenance and glass panels at least 9 by 12 in. may be added if desired.

* * *

Automatic Diesel plants have been demonstrated practical for standby, to start up on failure of regular power supply and to operate in parallel with steam units so as to supply power requirements beyond that available from the usable quantity of exhaust steam.

* * *

Condenser costs have decreased of recent years to from 30 to about 15 per cent of the turbine costs. With 400 lb., 750 deg. F. steam an increase of about 7.5 per cent of heat energy is made available by increasing the vacuum from 28 to 29 in. This is comparable to the increase available by increasing throttle conditions to 800 lb., 770 deg. F.

* * *

Tempering dry coal with water or low pressure steam improves combustion conditions on chain grate stokers because it gives more uniform fuel bed conditions.

In order to keep the shop working area entirely clear in a single room 204 by 304 ft. of the Boeing Aircraft Co. all air, steam, water, gas and electric lines are run in tunnels. The main tunnel 6 ft. wide and 7 ft. high runs outside the building and the top slab will form part of the floor when the building is extended. Six tributary tunnels lead under the assembly floor with steel framed manholes at 40 ft. centers for all service connections including portable tools and special lighting.

* * *

In cooling air from above 32 to below 32 deg. F. six heat quantities must be considered: Sensible heat of vapor to the due point; latent heat of the vapor condensed; sensible heat of the condensate between the dewpoint and 32 deg. F.; latent heat of the water frozen; sensible heat of ice and vapor to the final temperature; sensible heat of the air.

* * *

For use on Diesel spray valves and fuel pump plungers the Navy uses shredded lead alloy packing with the strands laid parallel and impregnated with not more than 5 per cent of flake graphite and oil. The alloy is about 95 per cent lead with 4.5 to 5 per cent tin, not more than 0.25 per cent antimony or 0.25 per cent impurities.

FOR THE PLANT ELECTRICIAN

Calculating A. C. Motor Speeds

By Eugene George Key

THE FORMULA for finding the synchronous speed of a.c. machinery (the speed at which an a.c. motor must rotate to match the speed of the generators) is:

$$S = \frac{120f}{p} \quad \ldots\ldots\ldots\ldots (1)$$

where S is the speed in r.p.m., f is the frequency in cycles per second, and p is the number of poles in the machine whose speed is under consideration. Sometimes, however, an operator may wish to know the speeds at which several motors of the same frequency will run. When it is used once, (1) is a convenient formula to use. When it is used several times, it becomes cumbersome and monotonous.

A short cut is to find the fastest speed at which a motor of a certain frequency will run. At all frequencies, the fastest motor has only two poles. Formula (1) will show that this motor will rotate at 3600 r.p.m. on 60-cycles. Remembering this speed as a constant, all other speeds can be calculated by

$$S = \frac{F}{p \div 2} \quad \ldots\ldots\ldots\ldots (2)$$

where F is the speed of a two-pole motor at the same frequency. Thus, to find the speed of a 12-pole motor, 3600 is divided by 6 and the result is 600. For a 25-cycle motor, the speed F is 1500, and the speed of a 12-pole motor is 1500 divided by 6, or 250. This same formula (2) can be used for all frequencies after the speed F is found for a two-pole motor at any particular frequency from Formula (1).

Electric Motor and Controller Inspection

By FREDERICK OAKHILL
Plant Engineer
United Wall Paper Factories, Inc.
Chicago

THE INSPECTION of electric motors and controllers should be done by a qualified individual who will make the inspections on a routine basis. The task of making such inspections is simplified when each piece of equipment is checked against a questionnaire inspection sheet.

To aid the inspector, the following items are listed for his attention:

1. Clean off motor, particularly all ventilation ducts and windings.
2. Check condition of windings.
   (a) General condition of insulation.
   (b) For oil soaked coils.
   (c) For hardened oil or grease on coils.
   (d) For bare or skinned conductors.
   (e) For poor taping.
   (f) For clearance between coils and rotating parts.
3. Check condition of armature or rotor windings. Check items a, b, c, d, e, and f as above.
4. Check bearing oil level.
5. Check condition of bearing oil.
6. Check for possible oil leakage.
7. Check to see that oil rings move freely.
8. Check condition of oil well covers and drains.
9. Check condition of bearing dust seals if used.
10. Check any tendency of one bearing to heat more than the other.
11. Check tightness of bearing retaining screw.
12. Check amount of end play of shaft.
13. Check tightness and condition of gear or pulley.
14. Check tightness of lugs and connections at motor leads.
15. Check to see that squirrel cage rotor bars are tight in slots and at end ring connections.
16. Check air gap or clearance between stator core and rotor, or armature and field pole pieces.
17. Check condition of ground wire and ground connections.
18. Check tightness of motor on foundation.
19. Check for any tendency of motor to vibrate while running.
20. Check condition of slip rings or commutator. Commutator must be smooth, round, and the mica undercut or at least flush.
21. Check condition of centrifugal switch on fractional horsepower a.c. machines.
22. Check condition of brushes and holders (on slip ring, repulsion-induction or d.c. motors).
23. Check brush tension, brush setting, and see that brush connections are tight.
24. Check slant or angle of brushes with respect to direction of rotation.
25. Check condition and free operation of short-circuiting devices where used.
26. Investigate any unusual sounds or noises when motor is running.
27. Investigate any local heating of certain coils or group of coils.
28. Tighten all mechanical parts, belts, nuts, screws, etc.
29. Note time required for motor to accelerate when starting.
30. Test insulation-resistance of the machine with a megger or Wheatstone bridge.
31. Check load on motor with ammeter or indicating wattmeter.
32. Check controller contact points, solenoid coils, and mechanical parts.
33. Check all switch arms and jaws for burned spots.
34. Check fuses for proper size.
35. Check surrounding area for cleanliness or possible conditions that might be damaging to the motor and its equipment.

Of the above listed items take special note of: Clean windings, proper temperature of windings, open air ducts and ventilating ports, condition of insulation on windings, and bearing temperatures.

The following list of items are for the inspection of switching equipment:

1. If a knife switch; operate frequently enough to prevent oxidation of contact surfaces and keep jaws and hinges tight.
2. Check for poor contact, overheating, and connections to studs.
3. Is switch gear properly protected from mechanical, atmosperic and electrical injury.
4. Check oil level and operating mechanism of oil switches.
5. Check all parts of switch and operating mechanism to ascertain if in good mechanical condition.

The main point about any switch is that it is making contact without any undue heating effect.

Those plants desiring to establish a procedure for the maintenance of electrical equipment are referred to an article by the author published in POWER PLANT ENGINEERING, August, 1939 issue, Page 524. This article illustrated the various forms developed for a motor and controller maintenance procedure.

Notes on the Use of Vitreous Enameled Resistors

THE ARBITRARY full rating a vitreous enameled resistor is the load in watts which will produce 250 deg. C. (450 deg. F.) rise at the hottest part of a two-terminal resistor when suspended in air at least a foot away from the nearest object. The rating at which such resistors can be operated in practice depends of course upon the conditions of ventilation which exist in the vicinity of the installation. The above rating is based on an ambient temperature of 40 deg. C. (104 deg. F.). If the conditions of ventilation are not as good as those implied in the standard method of rating a temperature rise of 250 deg. C. will be reached at a correspondingly lower rating. Often it is necessary to operate resistors at half rating and where ventilation is poor, it may be possible to operate them at only quarter rating. When a number of units are mounted together, or when one or more units are partially or totally enclosed, the load which will cause the permissible temperature rise is materially decreased. Thus the load which a resistor will dissipate is limited by the conditions inherent in the application. While the limits are not critical it is well to keep these factors in mind.

AIR CONDITIONING

Water Economy in Air Conditioning

By T. H. BIEZE, Manager
Scarbrough Bldg.
Austin, Texas

IN THE SCARBROUGH BUILDING a Carrier air conditioning system has been in service since 1931. During that period no money has been spent in repairs or maintenance although some piping changes have been made in order to reduce the make-up water requirements and save some cold water.

About 2 yr. ago we found the temperature of water to the cooling tower ranging from 100 to 103 deg. F. and returning at 93 to 95 deg. F. The resulting high condenser pressure caused the compressor to surge and fully loaded or overloaded the 200 hp., 2300 v. motor.

A Terry turbine is located between the motor and compressor. One hundred pound pressure city water for cooling the oil bearings was supplied, then as now through three ½ in. pipes. Before the change this water ran into an open funnel. From there it drained to the sump pit and was pumped to the sewer as the basement floor is about 4 ft. below the sewer level.

Inasmuch as the city water runs around 84 deg. F. and the temperature rise through the bearing was slight, the piping was changed and the water piped to the cooling tower, thus lowering the temperature of the condenser water and reducing the makeup. This water is now carried through a 1½ in. line which connects with a 6 in. ell in the return line from the cooling tower as shown by the sketch.

As the city water pressure is from 100 to 125 lb. no pump is required. We have a series of valves in order to determine the water flow to the condenser. When starting up in the morning the funnel flow is used as formerly but after running a few minutes the funnel is cut off and the flow turned into the condenser.

Another change was in connection with the water removed from the air by the dehumidifier. The overflow originally went into the same sump as the bearing water. The water leaving the cooler runs from 36 to 38 deg. F. warmer so that it represented a considerable waste of cold water. After considerable thought and study of the problem, we closed the overflow valve and added a 1 in. pipe at the overflow level. This pipe goes first to a 50 gal. oil drum. From there it is pumped direct to the condenser on the return side of the cooling tower. Details of the return piping and valve arrangement at the condenser is shown by the detail sketch in the upper left-hand corner. No water from the air conditioning system now flows into the sump except as noted above for a few minutes in the morning.

The centrifugal pump, cross connected to empty the oil drum, is used only after the air conditioning plant shuts down at 6:00 p.m. to pump cold water to a coil, and three fans to cool a ground floor drug store until closing at 9:00 p.m. Moisture taken out of the air in the dehumidifier runs from 50 to 65 gal. per hr. depending upon weather conditions. On Friday, July 7, the outside temperature at 5:00 p.m. was 103 dry bulb and 73 wet bulb. The condenser water temperature was 90 deg. F. on and 80 deg. F. off the tower. The cooling water was leaving the cooler at 36 and returning from the dehumidifier at 44.5 deg. F.

Heat Loads

IN A MODERN OFFICE BUILDING the lighting load will run from 2 to 5 watts per square foot and constitutes a major factor in the air conditioning load. In a recent installation the lighting averaged 4.5 watts and was estimated as constituting 26 per cent of the peak refrigeration load as contrasted to 13 per cent for occupancy. The balance was divided as follows: incoming fresh air 28 per cent; fan power 6 per cent, and heat entering the building 27 per cent.

Glass brick has been used effectively for cutting down heat transfer without reducing the light from the outside. The cost is only slightly above double windows and unshaded, the heat gain is estimated at about half of that through unshaded factory type sash. Much remains to be done to evolve architectural designs which will utilize the full advantages of air conditioning. In the building mentioned above, about twice as long as it is wide, the ratio of 40 sq. ft. of gross floor area per foot of perimeter would, it is said, have been cut to 22 if the conventional design using light wells had been followed. Lights are installed in coffers in the ceiling to give a minimum of 35 ft. candles.

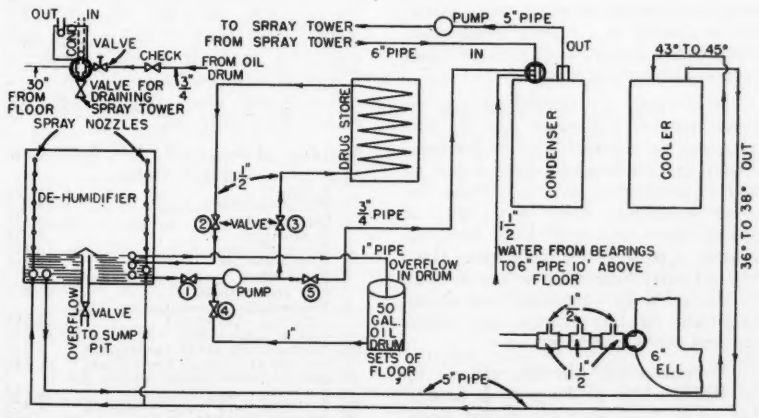
Air Filters

DURING RECENT YEARS many types of air filters have been developed and put into practical use to meet the varied needs of industry and air conditioning. The latter application in particular demands a low resistance filter, effectiveness on small dust particles and preferably constructed in small units easy to handle. While sprays and wetted cooling surfaces will, under favorable circumstances, catch a proportion of the larger particles, filters are more certain in their action, especially for the finer dust and pollens. Very fine particles such as found in smoke cannot be removed by filters but can be handled practically in one of three ways: by diluting with clean fresh air; by sprays; or by electrostatic precipitators.

Dry and viscous filters are usually made up in unit cells fitted in frames arranged so that the necessary capacity can be obtained by increasing the number of units. Velocities are normally kept to from 10 to 50 ft. per min. and the resistance or pressure drop to from 0.05 to 0.2 in. of water.

The dry type are cleaned by rapping, vacuum cleaning, washing or replacement of the filter media. The viscous type are made of wool, metal, glass, etc., some may be flushed and reoiled or others are discarded when dirty and a new cell inserted. When the dust content is unusually heavy an oiled or wetted screen ahead of the fine filter will materially increase the periods between the cleanings.

In industrial filters of large size velocities may run much higher, up to 300 or 400 ft. per min. At this velocity centrifugal action and impingement on deflectors, plates or screens coated with a viscous fluid prove effective. These filters can be arranged for continuous or intermittent automatic flushing. Resistances of industrial filters generally run from 0.2 to 0.4 in. of water. Oil bath filters of the type commonly used in portable engine intakes often have a resistance ranging from 3 to 10 in. of water.



Water piping in the Scarbrough Building showing how bearings cooling water and dehumidifier overflow was reclaimed from the sewer

BOILER AND STOKERS

High and Low Water

DURING REGULAR OPERATION, certain emergencies, such as high water, low water, priming and foaming and broken glasses occur and, at these times, the operator should follow a definite procedure.

In cases of high water, the forced draft should be cut off, the fuel feed stopped and the feedwater valve closed. Try gage cocks should then be opened to make sure the water is high. If they are readily accessible the superheater drains and the surface blowoff valves can be opened. If this is not sufficient the water level can be brought to safe working conditions by means of the blowoff valves. During this period the back damper should be practically closed, with just sufficient draft to clear the gases from the furnace.

Practically a banked condition should be maintained until the water level has been lowered to the desired point. If a feedwater regulator is used it should be taken out of service and the feed regulated by hand until the trouble is located. When normal water level is reached the boiler can be put back into service in the same way as from a banked condition.

LOW WATER

In low water the operator should first try to discover and remedy the trouble. If conditions become dangerous, close the feedwater valve to the boiler, cut off the forced draft and partly close the back damper, leaving only sufficient draft to clear the gases from the furnace. The fuel feed should be stopped and where possible the dump plates dropped, after which drown the fire and allow the boiler to cool. When the steam pressure drops below the header pressure the main stop valve should be closed and the trap line valve above the automatic non-return valve shut. The automatic non-return valve should be locked. After the boiler is cool, all vents between the automatic non-return valve and the boiler should be opened, the boiler inspected and subjected to a hydrostatic test to make sure that the low water has caused no damage.

PRIMING AND FOAMING

With priming and foaming the feed valve should be closed and the boiler banked. Afterwards the surface blow off valve and blowdown should be opened until the water level is lowered about one gage after which the boiler can be started as from a banked condition. If this does not stop the foaming, it will be necessary to shut down the boiler and wash it out.

BROKEN GAGE GLASS

With broken gage glasses, the lower and then the upper cut-off valves should be closed and the free blow-off valve opened. Glass and washers should then be replaced, the upper and then the lower cut-off opened and the free blow-off closed! All opening and closing of valves in this operation should be done from the floor level with the face shielded from a possible jet of steam, water or broken glass.

Boiler Costs

SOME WEEKS AGO a sharp eyed engineer, R. H. Keil, Senior Electrical Engineer, Western Electric Co., Hawthorne Works, Chicago, wrote: "I was very much interested in the third item of the section called Shorts on page 471 of the July issue of POWER PLANT ENGINEERING, in which the cost of a 450 lb. pulverized coal fired boiler completely erected was given (Quindaro Station at Kansas City, Kan.). For a 150,000 lb. boiler the cost by this formula would figure $120,000. On page 441 the actual contract cost for a 150,000 lb. boiler is given as approximately $250,000. While I appreciate that this is undoubtedly a more elaborate installation than the type referred to in the item under Shorts, the discrepancy in cost figures seems to be very wide. An explanation of the difference will be of considerable interest."

The Short on page 471 was taken from a paper presented by G. A. Gaffert of Sargent & Lundy, Inc., before the Midwest Power Conference (see p. 385, June, 1939) and refers specifically to small boilers which are ordinarily quite simple. In a letter Mr. Gaffert said: "the data on boilers included in curve form for the M.P.C. referred particularly to integral furnace type boilers which do not normally include economizers. This type of boiler is less expensive than the old standard types of bent tube or cross drum design . . . and could have been bought for that price in 1938." Quindaro Station, on the other hand, is anything but simple as can be readily appreciated from the fact that some $8000 was spent on a public address system which, while useful, can be classed as a luxury which other plants in the country manage to get along reasonably well without.

It is really an 180,000 lb. per hr. boiler with an expensive slag tap furnace and the contract price as given includes the combustion control and all boiler instruments as well. From the price breakdown there is no way of telling what else may have been included. Certainly the economizer alone was a considerable item to say nothing of the hydraulic couplings, coal scales, automatic lighting system, soot blowers and other trimmings.

A somewhat similar article by A. Kolflat, also of Sargent & Lundy, Inc., Fig. 5 on page 250 of the April, 1939, issue gives a good idea of the effect of pressure and size on price.

This was referred to the authors, R. L. Baldwin and A. C. Kirkwood, Burns & McDonnell Engineering Co., Kansas City, Mo., and Mr. Baldwin replied as follows:

"Information referred to in the small item on boiler costs under Shorts is no doubt based on the number of relatively small boiler jobs and to indicate how approximately correct this is, we give below a number of boilers that have been purchased within the last 2 yr. on our jobs.

"These boilers are all for 400 lb. working pressure with superheat to 700-750 deg. F. total temperature. The boilers are provided with water walls at side and rear. Most of them have air heaters. The settings are sectionally supported and all have forced and induced draft. However, these boilers were all stoker fired, and the price given includes the entire installation, complete and installed. The 50,000 lb. per hr. boiler includes combustion control, the others do not include control. The figures show a considerable variation in price as is natural in receiving bids on work.

Lb. per Hr.	Actual Cost Installed	Calc. from Formula
25,000	$41,990	$45,000
30,000	41,736	48,000
30,000	55,831	48,000
45,000	68,896	63,000
50,000	94,088	66,000

"The Kansas City, Kan., costs as you have indicated include the entire installation, complete with all auxiliaries with the exception of the coal scales. These scales cost approximately $2500. The water walls are provided with cast iron blocks, and the entire sides, as well as the bottom, are water cooled, and there are numerous items such as the automatic lighting equipment and hydraulic couplings for fan control that are not customary on ordinary boiler installations. Then the pulverizing equipment has excess capacity; in other words, each pulverizer is capable of carrying the boiler at about two-thirds load.

"We are giving a breakdown of the contract price, which indicates, at least approximately, the cost of the various component parts of the boiler. These prices, while not absolutely accurate, were used in making up estimates for payment to the contractor. The final cost was adjusted for some minor items, amounting to approximately $500 additional.

Breakdown of Kansas City, Kan., Boiler Cost, Quindaro Station

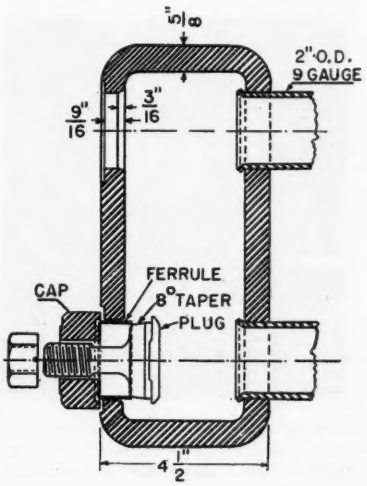
1.	Boiler	$ 41,981
2.	Water-cooled furnace	56,530
3.	Superheater	13,363
4.	Economizer	6,515
5.	Air preheater	13,770
6.	Soot blowers	4,864
7.	Steel work, brickwork, casing and insulation	15,374
8.	Pulverizing, combustion and lighting equipment	38,995
9.	Gas and air ducts	15,431
10.	Mechanical draft equipment	8,075
11.	Motors and control equipment	16,289
12.	Boiler instruments and combustion control	15,616
13.	Fittings and appurtenances	1,820
14.	Painting (estimated)	300
15.	Starting equipment and test	500
		$249,432

FOR THE DIESEL OPERATOR

Economizer Leaks

While Few Boilers outages can be laid directly to handhole and gasket leaks, such leaks should be taken care of at the first opportunity in order to avoid corrosion and erosion which may eventually cause permanent damage. At the Riverside Station of the Northern States Power Co. some 40 leaks were reported (E.E.I. Pub. No. F15) in three economizers over a 6 yr. period.

The economizer tubes are rolled into the return bends. Most of the leaks in tube rolls are caused by over-rolling the



tube at the time of installation. Leaks in the return bends were due to sand holes which are repaired by electric welding. The water temperature to the economizer during normal operation varies from 280 to 310 deg. F., and the temperature leaving the economizer, from 345 to 385 deg. F. The feedwater pressure is about 465 lb. per sq. in. Fluctuations in pressure and temperature apparently have no influence, as leaks have developed when the boiler has been held at a comparatively steady steam flow for several weeks.

The handhole in the return bend is a round hole with straight sides as shown by the drawing. The seat is made by placing a ferrule over a slightly tapered plug and drawing it tightly into the hole. The width of the seat is about ¼ in. which will vary somewhat depending on the number of times the plug has been removed.

Clearance between the return bend and the plug with reference to the seat is about 0.06 in. The gasket consists of an Armco metal ferrule; the ferrule is ⅞ in. long, 1/16 in. thick, slightly tapered, and with a bevel on the small end. There is no definite procedure in preparing the seat, only that the surfaces be cleaned before the plug is drawn tight. A hydrostatic pressure of 650 lb. per sq. in. is applied to the economizer after the repairs have been made. Damaged seats and the return bends are repaired by electric welding and remachining.

Engine Mufflers

Except in a few cases where the power plant is completely isolated an unmuffled engine exhaust is undesirable because of the disturbance and annoyance to those who must live or work in the immediate vicinity. It is general practice to provide each engine with a muffler or silencer, the effectiveness of which depends upon the design. Where extreme quietness is necessary it is advisable to take the matter up with the engine manufacturer or one of the manufacturers specializing in silencers. This is particularly true in the case of 2 cycle engines which are more susceptible to pressure conditions in the exhaust system, so much in fact that engine operation may be seriously affected by resonance conditions in the exhaust pipe[1].

On the larger size engines of the 4 cycle type, the muffling arrangement illustrated has been found a satisfactory and economical solution and is recommended by the A.G.A.[2] for gas engines operating under average conditions. The exhaust pipe assembly should be welded together as illustrated with the pipe of the same diameter as that leading from the engine exhaust manifold. The distance between the two vertical members of the assembly should be equal to four times the diameter of the pipe.

The exhaust pipe should have slots burned in it to approximately 18 in. above the lower right angle bends so that the total area of the slots will be equal to three times the area of the pipe. These slots should not extend higher than within 3 ft. of the ground level. A pit should be dug of such dimensions that the exhaust assembly, when placed in it, has a clearance of at least 12 in. at the sides and ends, and 18 in. at the bottom. The hole should be filled with rock crushed to 1½ in. and covered with a 6 in. concrete slab. The exhaust or tail pipe should extend at least 10 ft. above the ground level.

To help carry the heat from this pit, it is advisable to install a vent pipe in it before the rock is put in and the concrete slab put on. This pipe should have a diameter equal to the exhaust pipe and should extend about 1.5 ft. into the pit. If still further quietness is required, a muffler can be installed on the end of the exhaust line leaving the pit.

Rulings of the National Board of Fire Underwriters and local ordinances should be consulted so as to be certain that the handling of the exhaust will conform to such regulations.

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[1]See **Eliminating Engine Exhaust Noises.** Power Plant Engineering, p. 188, March 1939.

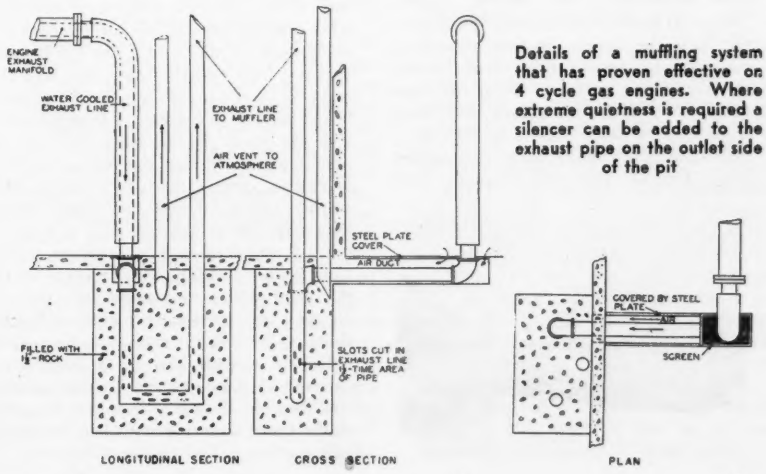
[2]**The New Gas Engine Handbook** is available from the American Gas Association, 420 Lexington Ave., New York City, for $1.00 a copy.

* * *

The switch house of the Grand Rapids Stamping Div. of General Motors consists largely of glass brick which gives insulation equal to a 12 in. brick wall. The relative humidity is controlled automatically, not by removing moisture but by varying the temperature in accordance with the dew-point of the atmospheric air.

* * *

Centrifugal pump shafts should be packed with the metal lantern gland lined up with the sealing water pipe. The sealing water supply should be carefully watched especially with high suction lifts for a small air leak may cause the pump to lose its suction. The gland should be fairly loose so that there is a small leakage outward as well as along the shaft.



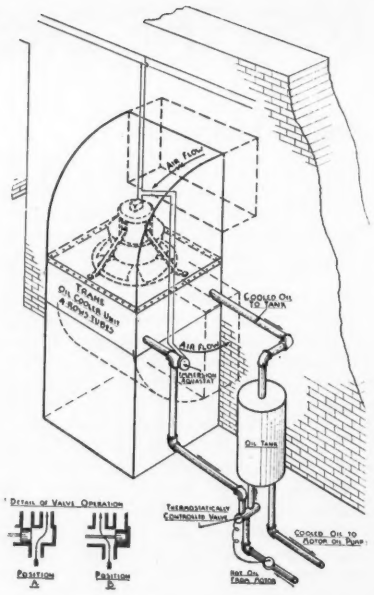
Details of a muffling system that has proven effective on 4 cycle gas engines. Where extreme quietness is required a silencer can be added to the exhaust pipe on the outlet side of the pit

Lub Oil Cooling

COOLING oil for the motors on test presented a problem at Stevenson's Field, the new airport base for the Trans-Canada Airways at Winnipeg, Man. The problem as it confronted the engineers was: To cool 9 g.p.m. oil from 200 to 175 deg. F. with a maximum outdoor air temperature of 90 deg. F. In casting about for a practical means of solving this problem, the engineers looked at the operating characteristics and inherent construction of an ordinary Trane Unit Heater. The drawing illustrates how this unit was adapted to serve the purpose.

Electric immersion heaters situated in the oil tank bring the oil to approximately the operating temperature of 170 deg. F. The engine is then started for the test and the pump on the engine returns the oil to the oil tank, at which time the thermostatic valve is in position "A." As the oil from the engine becomes heated, the thermostatic valve modulates and by-passes oil through the unit heater—or in this case, the unit cooler.

As the oil temperature rises further, the valve approaches position "B" in which all of the oil passes through the cooling unit. When the oil passes through the supply line to the cooling unit, it closes the circuit in the immersion aquastat and starts the fan of the cooling unit. The fan blows the considerably cooler outside air over the coils through which the oil circulates, and the desired temperature reduction is accomplished. The unit heater is a vertical flow model with a 4-row single serpentine coil and is located within the building but so arranged that it utilizes an outside air supply.



A unit heater arranged for air cooling of lubricating oil where a water supply was not available in a building isolated from water and sewer facilities

Flexible Gage Glasses

By Charles C. Lynde

LONG GAGE GLASSES on wooden tanks used for storage or process treatment of liquid materials are subjected to severe stresses as the tank staves shift under varying conditions of temperature, weather or degree of loading. As an alternative to the usual solution of this problem by installing a series of short gage glasses—with attendant multiplication of leakage possibilities—the Sun Oil Company installs one long gage glass to cover the desired range of liquid level in its treating tanks.

This long gage glass is divided at the center, and a five-inch insert of oil resistant rubber hose of the proper diameter to fit snugly over the glass, is inserted and clamped in place over the junction.

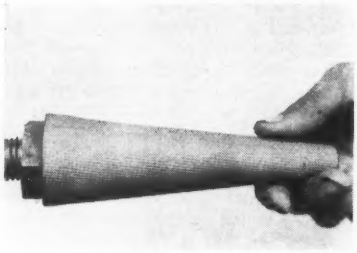
By using this rubber center, any shifting of tank staves or maladjustment of the two gage cocks is absorbed by the rubber tubing, and packing glands at the cocks may be tightened to any degree desired without fear of imposing excessive strain on the length of glass tube being supported.

PRACTICAL HINTS AND KINKS

Emergency Holder

By Frank Bentley

ON EMERGENCY repairs it is often necessary to remove fairly large machine nuts that are very hot and located in some inconvenient and unhandy places. The usual glove affording little or no protection to the fingers. In some cases it is necessary to remove them from the last thread or two by hand where they can accidentally drop into places and cause trouble. For many such jobs the above photo shows the handy use of a discarded heavy conical cardboard wrapping cord cone or holder, always thrown away by stores when the cord is used up off of them. They can be snugly forced over the top of a nut and will hold it securely and safely until shaken out. If the nut is smaller cut off enough of the large end of the cone to make it fit the nut when quickly pressed on for removal or application to the stud. The cardboard will not heat and the other end will always be cool for the fingers. The cardboard used in such cones is tough, heavy, and will stand the necessary pressure in handling nuts of any size when hot, inaccessible, and cannot be conveniently worked on or off with the fingers after they have been loosened with a wrench out of which they are liable to drop. Gets them off safely when turned off to the point where they might slip out of an open end wrench or socket, and gets them on for you far enough to be turned with the wrench into place and tight. Several of these discarded cones in the tool box or drawer will often be suddenly found a very handy help on such jobs.



Broken Taps

By W. E. Warner

WHEN taps break off flush with or below the surface of a casting or forging their removal is always more or less difficult. To loosen the grip inject some acid between the threads. This will etch and loosen them and will cause no permanent damage if the acid is not too strong or left too long.

Leave the acid in not longer than 45 minutes. Use an acid strength of about 75 per cent water and 25 per cent of either sulphuric or hydrochloric acid. Use just enough to go between the threads. Then get a copper rod a little smaller than the threaded hole and drive this onto the broken tap. The broken edge will be more or less jagged and much harder than the copper rod.

When this is done take a pair of pliers and put on the copper rod and work it backwards and forwards and in this way work the tap out.

When the tap has been removed wash out the hole with chalky or limey water to neutralize any acid which may remain.

Questions And Answers

A Troublesome Problem with Sawdust Cinders

CAN SOMEONE furnish a real and practical solution to the question of preventing sawdust cinders escaping from the stack? Spark arrestors are out unless they can be kept clean. Sawdust is the cheapest fuel here but the occasional passing of sawdust cinders is an annoyance to the neighbors.

W. M. W.

We're Sorry

LEO S. SWARTS whose reply to the CO_2 Bonus question was published on p. 807 of the December issue has called our attention to an error in the spelling of his name and the listing of his address. As published, the item was credited to Leo S. Swart, Newark, N. J. This was incorrect. It should have read Leo S. Swarts, Newark, *New York.*

Explosions and Boiler Protection

WHAT IS USED between the header and boiler to protect the latter in case of an explosion of the header? This refers to a burst header which may cause the boiler to prime and empty with a hot fire still in it. I have been told that such an accident happened at the St. Louis Exposition when an 18 in. elbow broke and caused the water to be pulled from several Heine boilers and ruined them.

Would it be practical to equip a flow meter with an overload switch or relay in such a way as to close the line in case of an excessive flow of steam?

J. O. R.

AS FAR AS we know, no special provision of this kind is in use and we are of the opinion that under present conditions it is much more important to protect the header from damage due to furnace explosions than it is to protect the boiler from damage due to header breaks. When cast iron fittings were in common use, cracks and breaks due primarily to temperature stresses were not uncommon but fittings of this kind have largely disappeared except for low pressures.

Another factor that makes the matter of less importance than formerly is the widespread use of superheaters. The pressure loss through the superheater and ensuing piping in a modern boiler is sufficient to limit the flow to a considerable extent even though the header does fail. Whether or not an automatically operated valve could be closed quickly enough to prevent damage is problematical. If it could, there is some question as to whether the quick stop at maximum flow would cause pressure surges and water hammer that might be more dangerous than the condition it was intended to correct.

Because of mention of St. Louis the question was referred to Mr. Kreisinger for information on this particular point for he worked in the plant. He also refers to some of the other points covered but the question is still wide open for discussion by those who may have opinions on the subject.

* * * * * *

* * * * I ASSUME that by header you mean the steam header or the pipe line carrying the steam from the boilers to the place of the use of the steam. It was thought that this question originated with an accident which occurred in St. Louis during the exposition in 1904. While I was at that time at the exposition I do not have any recollection of such an accident. However, such an accident could have happened in those days when cast iron pipe fittings were in common use on steam pipes.

Nowadays motor operated shutoff valves are used between the steam pipe and the boiler. The valve is placed between the superheater header and the steam pipe. The valve can be, and usually is, operated from some remote point so that the operator can shut the valve off without the risk of being exposed to the escaping steam. The end of the superheater header is about as close as the valve can be located to the boiler. The usual one large size pipe taking the steam from the boiler drum to the superheater has been abandoned because of its mechanical weaknesses and because it was difficult to obtain dry steam from the boiler.

It has been replaced by a number of small size tubes which are distributed over the full length of the drum and deliver the steam to the saturated steam header on the superheater. The large number of small tubes take the steam uniformly across the full length of the drum and there is much less chance of any water spouts being formed in the drum and the water being carried out of the drum with the steam. It also eliminates any flanged or threaded joints because the joints at both ends of the steam carrying tubes are rolled. The tubes make flexible a connection which is not subject to cracking that might occur on large size pipe fittings.

Probably an automatically operated check valve could be placed beyond the usual stop valve and the steam pipe. This valve would close automatically when the pressure within the steam pipe would drop below a certain predetermined point. Thus for example, if a pressure of 400 lb. is carried the automatic valve could be set to close when the steam pressure within the piping was reduced to 200 lb. A small by-pass could be located around the automatic valve to build the pressure in the steam header when the plant is started.

HENRY KREISINGER.
Combustion Engineering Co., Inc., New York, N. Y.

How Do Others Calculate Refrigeration Output?

WILL YOU kindly advise us of practical formula for arriving at the amount of refrigeration produced by the following: One steam driven, 2 cyl., single acting compressor, 11½ in. diam. by 14½ in. stroke operating at a constant speed of 70 r.p.m.; and one motor driven variable speed, 2 cyl., single acting compressor, 10 in. diam. by 10 in. stroke, running from 200 to 300 r.p.m.

In the past we have figured our equivalent refrigeration by the B.t.u. absorbed by the circulated brine but changes in our equipment now make it impossible to arrive at the amount of brine circulated without the purchase of expensive meters.

We have heard of a formula that 7000 cu. in. of ammonia gas compressed per minute is equivalent to one ton of refrigeration in 24 hr. Have you any knowledge of this formula, and if so, how accurate is it and how is it derived? If it is fairly accurate we could arrive at our tonnage very easily by developing a constant that multiplied by the revolutions would give us the equivalent refrigeration.

N. M. M.

The direct questions on capacity for given conditions can be answered quite accurately as explained in detail in an article, Refrigeration Compressor Capacity by W. R. Kitzmiller on page 681 of the December, 1935, issue of POWER PLANT ENGINEERING. This article considered all factors such as head pressure, liquid temperature, suction pressure and superheat and volumetric efficiency of the compressor.

Calculation of the necessary constants for given operating conditions is not difficult nor unduly involved, although 7000 cu. in. of ammonia per ton indicates a rather low suction pressure. For ice making the value would probably be closer to 5000 cu. in. and for air conditioning it might well be

HOW TO KEEP POSTED?

From out where the tall corn grows, R. L. J. wants to know how other companies "Keep employees familiar with their own company's departments, new developments and new methods of operation. Also closely related, how to keep employees interested and their knowledge up-to-date so they don't become stale."

This matter of employee relations is receiving increased attention in all size plants. Here is an opportunity for one side to tell what they are trying to do and the other side to tell how well they are succeeding. A plan may look fine on paper but if it has not the support of the employees it is doomed to failure. The proof of the pudding is in the eating—not the recipe. Let's help R. L. J. out of his problem—he sounds very discouraged.

around 3000 cu. in. This makes no allowance for the volumetric efficiency of the compressor. The compressor displacement will run from 15 to 50 per cent higher, depending on the particular design and compression ratio.

Of more general interest is the methods used in different plants for measuring the refrigeration produced, how accurate they are in practice, how costly the necessary instruments are, how much of a burden it is on the operators and most important is the expense and bother justified.

Certainly some engineers in the country have had the practical experience necessary to answer these questions.

Corrosion Protection of Heaters

ON PAGE 677 of the October issue, it was explained in reply to O.T.'s query, how a heater could be properly preserved by the application of a special paint and this doubtless will solve his problem.

For general information, however, it might be added that in many instances heaters can be preserved from corrosive action by thoroughly wire-brushing the shell and heads, and then applying a cement paint, prepared by mixing sufficient water with Portland cement to form a paint (use no sand) for the internal surfaces. It has been found that this type of treatment of a vessel does prevent further corrosion, but it will be necessary to open the vessel at intervals to ascertain whether it has been broken down by the breathing action of the heater while under pressure.

Broadly speaking, this type of wash will last for a period of 9 to 12 mo., although to be on the safe side the vessel should be opened and inspected from time to time. This inexpensive method has been applied to many objects and the results have been more than satisfying.

In the event new heaters, tanks, or other pressure vessels are to be installed, it might be well for O.T. to give some attention to the new alloy heaters that are now being built. Some, manufacturers are now applying a thick cement lining to the vessels, but from one point of view, it would appear that if this cement lining should crack, considerable corrosion might take place underneath the lining. If not discovered in time, serious consequences may ensue. Also, to prevent corrosion, the purchaser can specify that the vessel be completely galvanized after it has been built.

H. B. S.

Ed. Note: It should also be pointed out that there are other commercial products on the market for this purpose some of them in fact being used for the prevention of corrosion and scale adhesion in high pressure boilers where the service is much more severe.

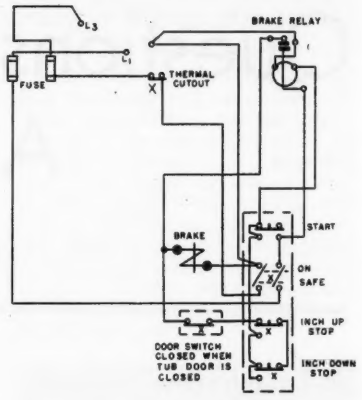
The Magnetic Brake Problem Is Solved

CAN ANYBODY solve this problem? Very definitely they can! When Mr. A. H. Parker of Peterboro, N. H., asked for help with his magnetic brake trouble (page 737 of November) we thought he was suffering alone. Apparently, however, anything can go wrong with a magnetic brake and generally does whether it be in New Hampshire, California, or somewhere in between. Certainly with the trouble shooting tips below there is no excuse for a noisy brake, longer disturbing the peace of mind and disposition of any engineer.

* * *

I HAVE had the same trouble develop with a Troy washing machine, installed in the Arlington Hotel a little over 3 yr. ago. About 2 mo. ago this machine started a humming sound in the brake which later developed into a clatter. It occurred for a few minutes at a time with maybe 2 or 3 da. between times. After a few weeks it occurred more often, so I began hunting for the trouble.

Tracing out the brake and brake relay circuit the trouble was found in the contacts on the starting switch which had became corroded by steam and fumes of chemicals used in the water of the washing machine. Also the spring tension on the contacts had weakened until the vibration of the machine would cause an opening of the circuit sufficient to let the brake chatter, yet not enough to allow the machine to stop.



After cleaning and adjusting the contacts on the starting switch I have had no more trouble. The wiring diagram of the brake circuit has an X marked on the contacts referred to.

A. W. SINDLINGER.
Chief Electrician,
Hot Springs, Ark.

* * *

THIS QUESTION makes no mention of the electrical split phase or shading coil which should be a necessary piece of equipment for every alternating current solenoid or magnetic brake. We have many brakes and coils of this type at this hospital and as we do all our own work we have to repair them.

One on the brake of our dumb waiter acts as he has described. The shading coil is made of brass imbeded in the pole piece and has no electrical connection or function other than to reduce the hum of alternating current. The vibration of the brake has a tendency to crystalize this brass which then cracks. Sometimes this is not visible but when the brake is in operation and we push the two sides together the noise will stop. I put new coils in several times but after a few months they would also break, so we took a hacksaw and enlarged the space through the pole piece and put a flexible copper wire through, along side the brass and soldered it at each end of brass. We have had no trouble since.

Would advise Mr. Parker to look in an elevator parts catalog where he can see the parts disassembled, or at any good magnetic switch which will have the brass or copper imbedded in the face of the pole piece. If his brake does not have this now it is easy to make. Apparently his brake assembly is for direct current which does not need the shading, or as we call it a split phase, coil to shade out the eddy current. The pole pieces of an alternating current coil must be laminated iron not solid as in direct current.

We have an automatic change over switch that changes our electric lights from the public supply lines to our automatic plant. This switch is held up by the a.c. and falls to the d.c. upon

failure of the public system. A constant hum was present in our switch board room just under the main lobby. The a.c. pole piece had a copper short circuit shading coil. We first doubled the size of this shading coil and then installed a resistance in series with the holding coil. A movable contact is carried by the switch so that the holding coil takes full voltage to start closing but when closed the resistance unit is in the circuit. This coil formerly took 750 watts 24 hr. per da. It now takes but 115 watts and there is no hum.

I have found that if the shading coil is properly installed the face of the magnets do not necessarily have to be perfect, our passenger elevators have this type of magnetic brake with the coils in oil, some times if the pole faces get dirty the brake will growl and can be heard for some distance but when the shading coil breaks it sounds like a boiler factory.

CYRIL A. MCGRATH

San Bernardino, Cal.

* * *

IN MY opinion he won't be able to install a brake which operates noiselessly because there is a slight whirring sound due to the centrifugal force. I understand the friction discs are mounted on the shaft and when the motor is at a standstill the magnets press against it. Mr. Parker should remove them and press a wheel, solid and about 8 in. in diam., on the shaft. The circumference must be grooved as for a V-belt drive. The brake circuit must be in parallel. This kind of installation has proved very satisfactory on U.S.A. post office conveyors. I do hear noises from slight irregularities of alignment of the bearings, but never a clattering din of the magnetic brakes.

New York, N. Y. CARL EGERTER

* * *

WHEN Mr. Parker asks if anyone else has had trouble with magnetic brake motors I can say I believe I have had. I am an operating engineer for the Wasco Creamery, which manufactures considerable ice cream and has two cold rooms, one directly below the other, for hardening and storing. In order to transfer cans of ice cream from one room to the other we have a small elevator operated by a magnetic brake motor.

This motor was in service about 3 yr. when it developed a noise comparable to that which Mr. Parker experienced. The motor and brake would operate but with an awful clattering noise. While I have had no previous experience with this type of motor I have had considerable electrical experience and my first impression was an open circuit. I knew this could not be in the motor itself or it would not start or if it did start it would not be so noisy, so the trouble placed in the brake coils.

After taking motor and brake assembly apart, I found the brake coils connected in a three phase star connection and was quite sure then that in one phase of the brakecircuit there was an open circuit. In checking all the intercoil connections and I soon found a broken wire which was repaired and since then the motor has worked perfectly. Vibration of the brake assembly no doubt caused the wire to break.

ALLAN VANDAM

Bakersfield, Cal.

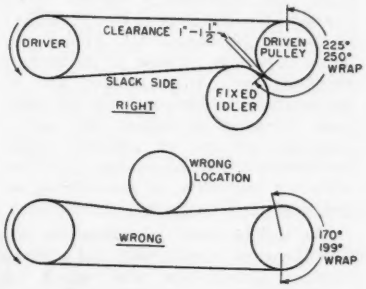
* * *

IN REPLY to Mr. Parker I can say with assurance that the difficulty is residual magnetism in the brake head magnets. To overcome this, the magnets must be milled out about ⅛ or 3/16 in. wide and ¼ in. or more in depth and filled in with a good grade of brass. This is to be done on the face side of each half of the magnet (two to a half side, total four). This will give quiet operation and also banish sticking of plates.

Philadelphia, Pa. R. BALMER

Where the Idler Pulley Should Be Located

MY SOLUTION of where an idler pulley should be located is not at all in accord with Mr. Schaphorst's (page 728 November original inquiry by C.W.L. page 676 October). No matter what the size of the drive or the driven pulleys or the center distances of the pulleys, the idler pulley should always be placed on the slack side of the belt 1 or 1½ in. from the driven side or driven



pulley which is the point of transmission. The top diagram shows why. In the bottom diagram you can see that it would be a hard task to take up the belt stretch because of the distance. In addition it places excessive strain on the belt without increasing the tension on the pulley.

ROBERT KEMP

Grand Rapids, Mich.

* * *

ABOUT that idler pulley, it should be put close to the driven wheel and as it is tightened it will cause the belt to come in contact with more of the pulley's surface and it will also keep the load running more steady by eliminating the belt fluctuation.

Redmond, Ore. C. C. COLLINS

How Cracks in Furnace Walls Can Be Repaired

NO SOONER was the November issue in the mails than help came pouring in for M.N.G. (page 737). Some of these engineers depend on commercial products to do the job, others depend on their own "dope"—all are agreed however that the workmanship and care with which the crack is filled has a lot to do with the final result.

* * *

AS A RESULT of a number of years experience in erecting boilers and boiler settings I can report good success in the stoppage of air leaks in brick settings due to cracking of brick work by the following method.

Take equal parts of powdered fire clay and portland cement; mix them thoroughly together dry; then add pure ammonia and mix so that material is the consistency of a soft mortar. Wash out cracks or holes in brick work so that they are clean; apply mixture with a trowel, gently push or squeeze the mixture into cracks and then point off with trowel. This mixture will set in from 2 to 4 hr. and it will become as hard as the bricks. Although the mixture will be hard, it will expand and not crack.

When mixing this material it is advisable to do it out of doors as fumes of ammonia are very strong. I have had cracks repaired with this mixture last for a number of years and I am certain that if M.N.G. will try this, his problem will be solved.

Bay City, Mich. R. J. KEMPTER

* * *

THE FOLLOWING method of repairing cracks in furnace walls, I have found to be very satisfactory. If the cracks are very small I use Plicast No. 27 with a cement gun or trowel. For larger cracks I use Plibrico Jointseal with cement gun or trowel or make a grout and run in as cement. If the cracks are very large I use a plastic firebrick, pounded in with a wooden wedge or hammer.

Houlton, Me. T. H. HEMORE

* * *

FURNACE wall cracks can be easily repaired with Plibrico. I am engineer at St. Joseph's Hospital and we have three boilers in this place, two with stokers. Burned places in the fire box, we patch it up with Plibrico and it stays good and will not shrink. For cracks in the setting we take a dull chisel, pound the plastic in the cracks, filling them up all the way good and tight.

Marshfield, Wis. GEO. DAUL

* * *

IF THE cracks are not over 3 in. wide M.N.G. will find the repair to be a very simple job if he will use rock wool packed in crack as firm as possible to within at least 1½ in. of the outside of the boiler wall. Finish with a coat of Dearborn wall and crack sealing compound which stays pliable, never exactly dries out and will knit to the edges of the crack. I have had nearly the same experience and this was the only way it could be stopped, in fact I stopped a 3½ in. crack where the flue blower was directly at the crack. This has not given any trouble for 2½ yr.

Louisville, Ky. R. W. COOPER

Here are the solutions to Problem No. 5 presented in the November issue. This problem, as may be recalled involved the determination of sudden changes in flow of a direct current feeding a number of electrolytic cells. As will be seen below the solution of this problem depends upon the use of a transformer, even though it has to do with a direct current circuit. Some used shunts and while it may possibly be solved by the use of shunts the simplest way is by the use of a transformer.

How Would You Do It?

ACCORDING to a late bulletin from the psycopathic ward our Board of Judges has appealed for an injunction restraining Our Hero from gaining access to any more chemical plants. After days of frantic and often seemingly hopeless struggle with the answers to Our Hero's last problem, which, as you may recall, concerned a detail in the operation of a chemical plant, they all but "passed out." If they got their whiskers tangled up last month over the rectifier switch problem, this month they tied them into hard knots, indeed some of the old boys haven't any whiskers left. Valiant old duffers that they are, they succeeded, however, in arriving at some agreement and in the end announced the prize awards. Their condition, after it was all over was sad indeed and we are unable to show a picture of them as we did last month.

The agreement they reached was largely to the effect that only a nitwit could propound a problem such as Number 5. Here again, as has happened before, the trouble was that everybody knew the answer and that made it extremely difficult to award the prizes. The rules of the contest state "that in case of ties duplicate awards will be made" and the judges had to do some keen thinking to get out of giving everybody a prize. As a matter of fact their mental gymnastics in this direction imply a decided Scotch ancestry.

The problem, as you know, involved the determination of infrequent instantaneous changes of current in a high capacity direct current circuit. Now, everybody that has even installed an electric door bell knows that you cannot use a transformer on a direct current circuit and Our Hero in his naive way thought that nobody would think of using a transformer in the solution of this problem, though in this particular case that was the proper thing to do. Well, Our Hero is something of an ostrich as well as a polecat.[1] With his head in the sand, figuratively speaking, only *he* did not know that practically everybody knew about the transformer. So, our Board of Judges was left with the unenviable job of trying to find a good excuse for selecting winning letters from a large number of solutions, many of which were basically alike.

The awards are made, however, not alone on the correctness of the solutions but on the analysis of the problem and the method of presentation as well, and from that standpoint it seemed logical to award the first prize to Carl C. Tinker, of Lapeer, Michigan. Mr. Tinker's solution is notable because of its inherent simplicity both as to method and his presentation and the possibility of home-made construction without the use of auxiliary circuits or complex relays. Furthermore, his supporting test data, while not conclusive, is, nevertheless, interesting.

As will be noted, he makes use of a simple current transformer and a simple sensitive locking-type relay which can be home constructed. The locking arrangement involves nothing more complicated than a permanent magnet which holds the armature in the closed position once a transient impulse has attracted it.

Pulverizer Pete as usual was a problem, indeed his solution almost created a riot among the judges. The trouble with it was that he seemed to take into account every possible method of solution under the sun. There were simple relay schemes and electronic methods and there were different ways of making and wiring relays. Furthermore, he tried it—he set up choke coil and purloined 350 v. d.c. from hs radio power supply and got hold of a milliammeter (Heaven knows where) and tried it. He says it works.

So what could the judges do but give him second prize and they did. Don't blame the judges too much—they are only poor old duffers trying to get along.

There was, however, another solution which also deserved second prize and so the judges made a duplicate second prize award to J. Bruce Stout of Oklahoma City, Oklahoma. Mr. Stout's solution also is simple and he makes use of standard equipment. His relays, however, involve auxiliary circuits. His suggestion of using a condenser across the secondary winding of the transformer is good.

Third prize goes to Harrell Denmean for his short but simple and effective solution. Mr. Denmead spends little time analyzing the situation but his solution is so direct and so obviously effective that there was no question as to the justice of the award.

The prize winning letters follow.

FIRST PRIZE AWARD

Problem V

By Carl C. Tinker

Plant Engineer, Detroit Edison Co.

The detection of sudden changes in current value in a d.c. circuit may be accomplished by utilizing the inductive effect of such changes. Sudden variations in current in the electrochemical circuit referred to in Problem No. 5 may therefore be brought to the operator's attention by connecting a current transformer in one wire of this circuit and providing a suitable alarm system connected to the secondary winding of the transformer.

As shown in Fig. 1 a current transformer is shown schematically and will require no further explanation. Connected to the secondary winding of the transformer is a relay which is shown more in mechanical detail. A bell alarm circuit is connected to the contacts of the relay. The relay is a single pole contactor type with a permanent holding magnet and re-set lever for manual operation. A trigger or latch mechanism might be used in place of the

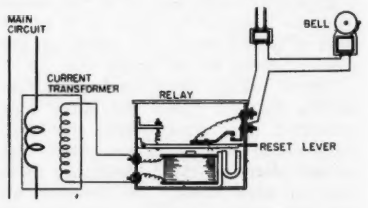


Fig. 1

[1]See last month's analysis of Problem 4, page 800 December issue.

permanent magnet to hold the relay closed once it has been energized, but the magnet was chosen in this case because it would be more suitable for a relay of the sensitivity required for this service.

In the operation of this device, it is apparent that a moderate current variation of short circuit suddenness in the main circuit will induce an e.m.f. in the transformer secondary sufficient to operate the relay, thereby closing the bell circuit and sounding the alarm. Once the relay is closed the holding magnet keeps it in this position until the operator's attention is called to the condition. He may then return the relay to the open position by means of the re-set lever thus shutting off the alarm and preparing the circuit for the next operation.

In the absence of any data concerning the characteristics of the main circuit it would be difficult to predict the exact rate of change of current during a short circuit condition. However, it might be assumed that when using a 200 to 1 current transformer a sudden 50 ampere variation in the primary winding would momentarily induce approximately 0.25 amperes in the secondary circuit, depending on the impedance of the relay coil.

A simple test of this condition while using a 20 to 1 current transformer and a 25 ampere variation in the primary circuit resulted in a 50 milliampere deflection through a 100 ohm secondary load. Ignoring possible error owing to the inertia of the moving element of the instrument used, this would indicate that there were 250 milliwatts available for the operation of the relay for this particular condition. However, I believe that we should allow our Hero to carry on from here since he will have no difficulty in selecting a relay of the proper impedance and sensitivity. And the bell circuit will be right in his line.

SECOND PRIZE AWARD

Problem V

By Pulverizer Pete

So now we comes to Problem No. 5 in which your Hero fiddles with electrochemistry. And I looks at this here chart you two has cooked up and says to myself, I says, "Obviously, ye Editor wants I should take apart my radio and give him the relayed-automatic volume-control-resistor-capacitor network hooked up in reverse to an electron tube relay, a photocell and probably a cathode ray tube; because he likes electronics."

I lights up my Sherlock (seldom) Holmes deducing pipe and pretty soon comes to a brilliant conclusion that is gonna give you a shock and it ain't gonna be from your 800 Amps. You ain't gonna get any electronic circuit out a me—my answer is: use a current transformer. Now, hold on and don't get excited, you ain't a alternator; we both knows, at least I hopes we *both* does, that transformers don't work so good when hooked direct on to D.C. But has you got D.C. like you says?

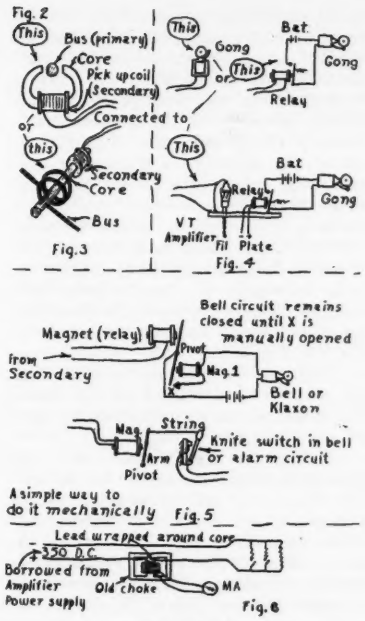


Fig. 2 to 6

The answer is not when your current is making the jump, up or down which jumps you want should sound a alarm or something. These jumps is a pretty good imitation of A.C. for the time being. So if you had a transformer with the primary in series with the 800 Amp. circuit an E.M.F. (juice to you) would be induced in the secondary every time the current makes one of them *quick* jumps you draws on the chart; but there ain't no juice when the D.C. is steady or slowly going up or down like on the rest of the chart.

But now I can hear you hollerin, "Where does I get a current transformer for to carry 800 Amps. in the primary?" "I dunno," I answers, so I tells you how to make one. So what is a transformer? Quiet! I answers that: It is two coils a wire on a iron core; an E.M.F. going into one coil causes electromagnetic wiggles in the core which wiggles cause a E.M.F. to come out of the other coil. Now your 800 Amp. bus has got a pretty good field of wiggles around it so probably if you puts a coil a fine wire on a "C" core like picture 2 you gets pretty good pick up (induction, not blond) and juice enough in the secondary on the current jumps. If not you gotta wrap the bus in a circle a couple a times like picture 3.

If by now you ain't electrocuted you got a current transformer with a secondary full a juice when you get a rapid current jump. How much power you got I don't know, maybe it works your alarm as is. If not you can go to a electromagnetic relay or if even this won't work you can use a electronic voltage amplifier (at last you got a tube in the mess). See picture 4.

Of course you realizes you gets only one squirt a juice on each current jump, which produce one bang on a gong, waking up engineer as you said it has to. If he sleeps sound and you wants a constant racket until he wakes up you can make the jolt in the secondary operate a electromagnet or mechanical holding circuit which keeps alarm ringing until engineer drags self over to shut it off. See picture 5.

By now you has likely got idea which I tells you in advance is no good. You wonders why I don't put a potential

Problem No. 7

Our hero is a versatile cuss; if he is not worrying about turbines or pumps he has some electrical gadget and if it isn't electrical it is something else. This month his concern is over a refrigerating problem. It seems his refrigerating system has become temperamental and he has had trouble in keeping it balanced. The system is a small one involving an ammonia compressor serving two cooling rooms. One of these rooms is maintained at a temperature of around 40 deg. while the other is kept at 10 deg. The system has always operated satisfactorily but lately a slight change in load on the high temperature cooler has introduced difficulties. During certain hours of the day it is necessary to increase the load on the high temperature cooler and to carry this additional load the expansion valves on that cooler are opened up. The expansion valve on the 10 deg. room cooler is not touched, however. When the load on the high temperature cooler is increased, however, the temperature in the low temperature room goes down rapidly, in fact after about an hour it goes down to zero. Our hero first tried closing the expansion valve on the high temperature cooler but that did not help matters, indeed, often it was worse. Next tried shutting the expansion valve on the low temperature cooler but that did not help either—the compressor got hot. So, again, he is asking for your advice. What can he do that will enable him to vary the load on one cooler without affecting the temperature of the other? Is this a common fault inherent in such a system or is it due to some simple factor which has not been taken into consideration? What would you do in this case?

transformer across circuit instead of fiddling with pick up from bus. The answer is if primary resistance is right at one current flow say 800 Amps it ain't at 100 Amps and chances are: Boom! No more transformer. Any anyway why make a direct connection to a circuit what has got a little kick in it when it ain't necessary?

Hoping this is the answer you expected and also hoping you remits me first prize promptly, I am

Inductively yours,

Pulverizer Pete.

P.S. If you promises me first prize I will figures out how much wire to put on secondary.

PP

P.P.P.S. Don't tell me my answer ain't no good because I tried it like picture 6 and it works.

PP

P.P.P.P.S. For 50 bucks I promise not to answer next problem.

PP

DUPLICATE SECOND PRIZE AWARD

Problem V

By J. Bruce Stout
Oklahoma Gas & Electric Co.

A signal such as a bell or horn will be the answer to Our Hero's Problem of detecting instantaneously a fluctuation of direct current supplied to the electrolytic cells if, of course, the signal sounds simultaneously with the current change. The following scheme, being simple, practical and economical is hereby suggested.

The diagram, Fig. 7, illustrates all necessary equipment and electrical connections.

A standard instrument transformer rated at 1.2 kv. and 1000/5 amperes is connected in one side of the direct current circuit. The secondary winding of this current transformer is connected to No. 1 coil of a double coil relay. The No. 2 coil of the relay is connected through a contact to a 110 volt A.C. or D.C. local power source. In this circuit is a single pole, single throw push-button switch which is normally closed, but which, when pushed, will open the circuit to the No. 2 coil after the relay contacts have been closed. The other contact is connected to complete the bell, or signal, circuit to the local power source.

The operation of this scheme is indeed very simple. A steady flow of direct current through the primary winding of the current transformer will not induce a current in the secondary winding. Neither will a gradual change

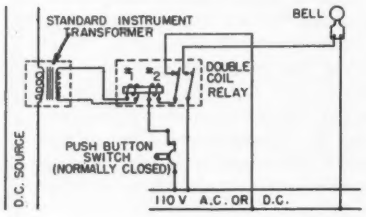


Fig. 7

in the direct current effect an induced current in the secondary winding. A sudden change, however, in the direct current, such as described, will cause a momentary induced voltage in the secondary winding of the current transformer, which will cause the relay to operate by virtue of a momentary current pulse through the No. 1 coil, and thus effect the closure of both relay contacts. Consequently, when the relay operates, No. 2 coil will be energized from the local source, hence causing the bell, or signal, to sound continuously until the operator presses the push-button switch so as to open the circuit of the No. 2 coil.

Obviously a mechanical-latched relay may be used instead of the double coil relay, which will eliminate the need of a push-button switch.

The writer has assumed that the change in direct current is not so sudden that it will fail to cause an induced voltage in the secondary winding sufficient to energize the No. 1 coil of the relay. The action of the transformer primary winding will act somewhat as a choke to slow down the direct current change. But if the change is still too rapid, a condenser may be shunted across the secondary winding and No. 1 relay coil so as to discharge through the coil and assure positive relay operation on very sudden changes of direct current.

After installing the current transformer, tests can be made during direct current changes for determining the voltage induced in the secondary winding of the transformer. A relay may then be selected which will operate under actual conditions as found by the tests. There are a great many different kinds and sizes of relays to select from, which is the main reason for this suggested procedure.

Of course, it is obvious that a relay having suitable characteristics must be employed. Because of the relatively low price of such relays a standard current transformer is therefore suggested rather than a specially constructed transformer which would give higher secondary voltages during changes in direct current, and therefore make it possible to utilize, for example, a standard 100 volt relay.

THIRD PRIZE AWARD

Problem V

By Harrell Denmead
System Operating Engineer,
West Penn Power Co.

Install an 800/5 current transformer in D.C. leads. Connect a Model 730 Weston sensitive alarm relay in the secondary leads. Connect contacts of relay to required alarm. (See Fig. 8)

On normal slow rise of direct current there will be no corresponding use in secondary. However, any sudden rush of current will cause a corresponding indication in secondary.

General Comment

It will be seen that the four solutions presented above cover almost every aspect of the problem and Our Hero should have little trouble in deciding for himself what he wants to do. All of these answers involve the use of a transformer. There is one point about the use of a transformer that should be commented on and that concerns the saturation. As a rule when a transformer is to be used on direct current, that is where direct current may flow through one or more of the windings, it is necessary to include an air gap

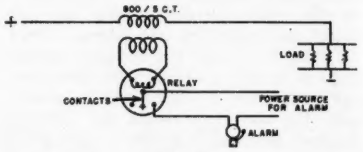


Fig. 8

in the magnetic circuit to reduce the possibility of attaining saturation. None of the above solutions mention this but Pulverizer Pete's idea of a transformer does take it into account.

A quite different way of attacking the problem is that submitted by E. B. Heise, Electrical Engineer, Northern Indiana Public Service Co. This is shown in Fig. 9. He makes use of a differential relay principle which depends for its action upon the unbalance created in two parallel circuits. Quoting from his letter:

"If the 50 ampere current changes are of short circuit rapidity, I would provide two parallel current paths of exactly equal resistance but include some inductance in one of these two paths, this inductance could be a few turns of cable around an old transformer core or an old current transformer of 400 amperes or more capacity with the secondary removed.

"In this arrangement any amount of current in a steady or slow changing state will divide equally in the two parallel paths while a sudden increase of current would cause a greater part of the current to momentarily flow in the non-inductive path while a sudden decrease in current would cause a greater part of the current to momentarily flow in the inductive branch of the circuit.

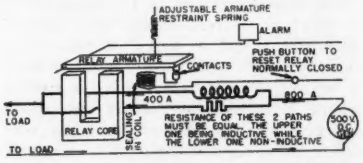


Fig. 9

"These parallel circuits could then be passed through the magnetic circuit of a small relay or contact making meter in opposition so that the magnetic lines of force set up by one conductor would be equal and opposite to second conductor thus the net magnetic effect would be zero, but any sudden change in the amount of current flowing would create an unbalance and operate the relay momentarily, this relay should be provided with a 'sealing in' coil in its alarm contact circuit such that once its contacts are closed they are held in the closed position by this 'seal in' coil and remain

so until the operator has heard or seen the alarm and pushed the reset button which resets the relay for the next operation. Several trial adjustments of the armature air gap and restraint spring may be necessary to secure the proper operation of the relay."

This scheme undoubtedly would work but with 400 amp. conductors the construction of the relay would present quite a difficult problem.

For pure unadulterated ingenuity, the solution by Russell D. Purrington of Pittsfield, Mass., takes the cake, however. He uses—but we will let him tell about it himself. "I suggest that a large face indicating ammeter with face horizontal be hooked into the line on which the variations occur. . . . The ammeter does not have to be calibrated but it should have a 0 to 1000 amp. range. The pointer of the ammeter is detached and a light prick punch mark is made near the arrow point at the top. This punch mark is made so that a ⅛ or ¼ in. dia. ball bearing will ride in the depression. On the face of the meter directly below the arc of a circle which the projection of the prick punch mark would make on the face of the meter are fastened two strips of copper insulated from each other and mounted as shown in Fig. 10 to form a circular trough. Their distance apart is such that the ball bearing when it falls off the pointer will fall into the trough and make contact with both strips of copper. This closes the circuit through a bell or other signal device. This ammeter is connected into the load line with the ball bearing balanced in the punch mark. Any gradual change in current moves the pointer slowly without dislodging the ball bearing. A sudden change of current will, however, move the pointer suddenly and the ball bearing by virtue of its mass will be dislodged and fall into the trough."

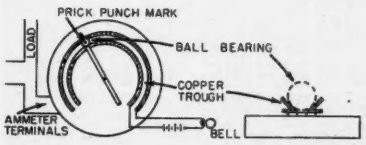


Fig. 10

There is no question about this scheme working and it is interesting to see how one starting with an entirely different basic idea nevertheless arrives at a practicable, if somewhat curious, solution.

Many contestants submitted solutions using electron tubes. Nearly all of these were excellent and there is no doubt as to their effectiveness, but in this particular instance the problem can be solved without electronics. An excellent electronic solution is that shown in Fig. 11 submitted by E. M. Fry, Jr., of Fanwood, N. J. Mr. Fry is aware of the effect of saturation in his transformer and it is to his credit that he comments on it. Quoting: ". . . the instrument transformer is shown with a single turn primary carrying the direct current. The secondary winding consists of many turns of fine wire. The only precaution to watch is that the core is not saturated so that you are operating over the knee of the flux curve. The secondary of the transformer is connected to the grids of the FG 178 thyratron through current limiting resistors.

"The FG 178 was chosen as the most satisfactory tube because temperature changes from —20 deg. C to +50 deg. C. have no effect on the operating characteristics of the tube. The thyratron will pass an average plate current of 125 milliamperes but the relay specified is 50 ma. to insure long life. There are quite a few rugged relays which will meet the requirements readily and so a limiting resistor is shown so that any available relay may be used. The lower portion of the diagram is a conventional rectified power supply. The potentiometer A is used to set the grid bias on the thyratrons.

"The operation of the circuit is as follows: The voltage regulator tubes 874 maintain 90 v. output each with relatively large changes in line voltage.

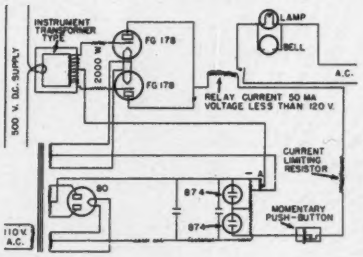


Fig. 11

This stabilizes the plate and grid voltages on the thyratrons. The potentiometer A is set so that the negative bias is so high that the tubes will not conduct at the existing plate voltage. A sudden variation in current occurs and the grid of one tube becomes more negative while the grid of the other tube becomes more positive. This slight decrease in negative bias on the thyratron allows the tube to start conducting. The relay is energized and the alarm starts to ring and the light comes on. In order to reset the equipment it is necessary to open the plate circuit or drop the plate voltage to a point where the grid again takes control and this has been done with the momentary push button. The deionizing time is approximately 1000 microseconds on the FG 178 so the button can be returned instantaneously to the normally closed position. It will be necessary to set the grid bias high enough so that minor variations do not trip the circuit. One tube will start to conduct when the variations are in the increasing direction and the other tube will conduct when the variations are in the decreasing current direction."

Another interesting solution is that submitted by Robert W. Olin of Potlatch, Idaho. He submits two drawings (Fig. 12) one using a plunger type of relay and the other an induction type. Mr. Olin, however, unconsciously assumes that the circuit in question is an alternating current circuit and from this standpoint his solution has no bearing on the problem in question. It is interesting to know, however, that an arrangement could be devised which would operate on alternating current. As will be noted, there are two relays involved connected through a floating contact. As long as the current changes slowly the relays will keep in step but on sudden variations the damping mechanism attached to one of the relays will prevent its sudden movement and the two systems will be thrown out of step.

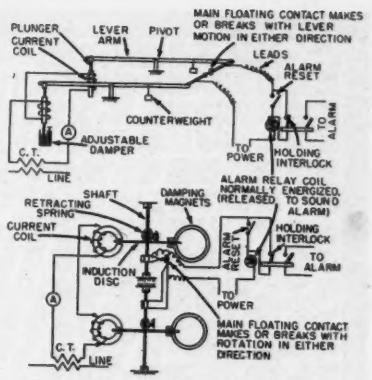


Fig. 12

There were a great many other interesting solutions to which we cannot give space here but we want to mention one final one—the one shown in Fig. 13 submitted by W. Freeman Smith. Mr. Smith makes use of a saturable reactor arrangement whereby any change of current in the d.c. winding affects the impedance of the a.c. windings. It seems as though something like this would work provided the magnetic circuit could be made to operate over the proper portion of the saturation curve.

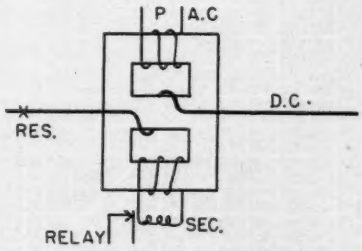
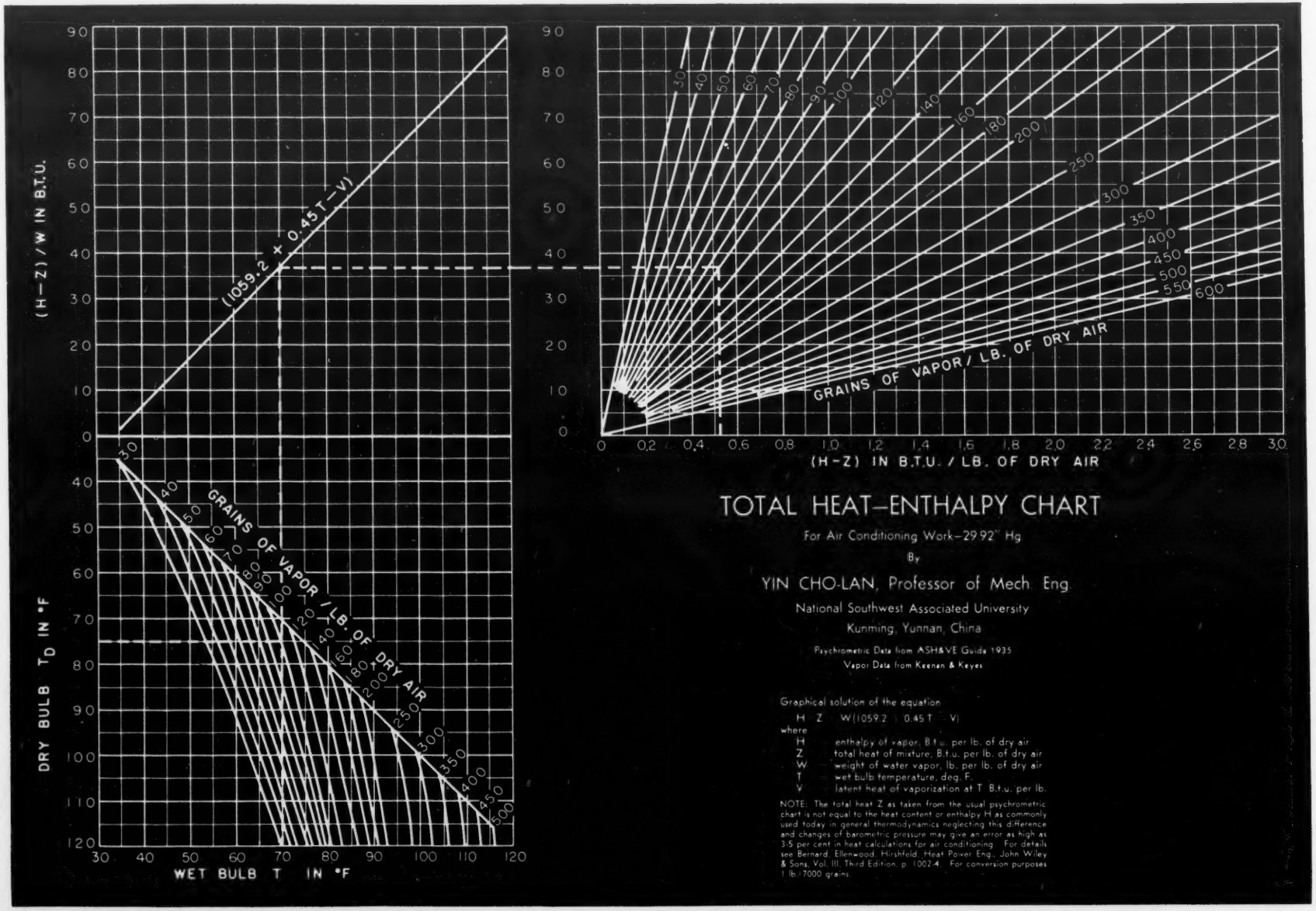


Fig. 13

The most ingenious solution of all, cannot be commented on in this issue since it arrived long after the "deadline" and just as this material is going to the printer. It is one by Albert Ogent, whom, as you may recall, submitted the test-tube solution to our switch problem last month. Mr. Ogent's solution of Problem No. 5 makes use of a mechanical-electrical system which to say the least is ingenious though somewhat complex. If there is room somewhere in next month's issue we will try to present some of the details. In the meantime our judges are puzzling over it.


(H − Z) / W IN B.T.U.
(1059.2 + 0.45T − V)
GRAINS OF VAPOR / LB. OF DRY AIR
(H − Z) IN B.T.U. / LB. OF DRY AIR
DRY BULB T_D IN °F
GRAINS OF VAPOR / LB. OF DRY AIR
WET BULB T IN °F

TOTAL HEAT–ENTHALPY CHART

For Air Conditioning Work–29.92" Hg

By

YIN CHO-LAN, Professor of Mech. Eng.

National Southwest Associated University

Kunming, Yunnan, China

Psychrometric Data from ASH&VE Guide 1935

Vapor Data from Keenan & Keyes

Graphical solution of the equation

$H = Z = W(1059.2 + 0.45T - V)$

where

- H = enthalpy of vapor, B.t.u. per lb. of dry air
- Z = total heat of mixture, B.t.u. per lb. of dry air
- W = weight of water vapor, lb. per lb. of dry air
- T = wet bulb temperature, deg. F.
- V = latent heat of vaporization at T B.t.u. per lb.

NOTE: The total heat Z as taken from the usual psychrometric chart is not equal to the heat content or enthalpy H as commonly used today in general thermodynamics neglecting this difference and changes of barometric pressure may give an error as high as 3-5 per cent in heat calculations for air conditioning. For details see Bernard, Ellenwood, Hirshfeld, Heat Power Eng., John Wiley & Sons, Vol. III, Third Edition, p. 1002-4. For conversion purposes 1 lb.=7000 grains.

A. S. M. E. the Guest of Philadelphia

Congregating for its 60th annual meeting, the American Society of Mechanical Engineers spent from Dec. 4 to 8 in discussion of a wide variety of engineering, scientific and educational problems.

FOR the first time since 1890 the Annual Meeting of the American Society of Mechanical Engineers was held outside New York city. Under the general committee of Philadelphians headed by Nevin E. Funk, a program of entertainment interesting to both men and women was arranged with headquarters at the Bellevue-Stratford Hotel, where all committee meetings and technical sessions were held. The arrangements resulted in a clubby, friendly atmosphere which was welcomed, particularly by those who came from a distance. The registration numbered more than 2200 and annual dinner exceeded all expectations with over 1100 in attendance.

In all some 34 simultaneous sessions were held and 102 papers presented and discussed. Mere numbers, however, do not give a conception of the importance to industry of the technical data presented at this meeting, for throughout the entire field of mechanical engineering the results of scientific research and investigation in the application of engineering principles to industry were reported to the Society.

President A. G. Christie delivered his presidential address on "Postgraduate Training of Young Mechanical Engineers" at the Annual Dinner, at which time also the 1939 Honors and Awards of the A. S. M. E. were bestowed upon their recipients. The Melville Medal was awarded to L. M. Goldsmith; the A. S. M. E. Medal to James E. Gleason; Holley Medal to Dr. Carl Edvard Johannson; Worcester Reed Warner Medal to Dr. Ruper Eksergian; Pi Tau Sigma Medal to John I. Yellott; Charles T. Main Award to James R. Bright; Undergraduate Student Award to David J. James; and the John Fritz Medal Award presented posthumously to Dr. C. F. Hirshfeld.

At the business meeting held Monday, the following officers were declared elected: President 1940 Warren H. McBryde, San Francisco, Calif.; Vice-Presidents (Terms expire Dec. 1941) Kenneth H. Condit, Francis Hodgkinson, Jerome C. Hunsaker and K. M. Irwin; Managers (Terms expire Dec. 1942) Joseph W. Eshelman, Linn Helander and Guy T. Shoemaker.

Plant Experience Discussion

Of outstanding interest to power engineers was the panel discussion on the past two years' experience with high-temperature, high-pressure stations. This review was contributed to by engineers from four typical plants. J. C. Falkner gave a brief description of the operation of the two high-pressure superposed turbo-generators, together with their boilers and auxiliaries at the Waterside Station in New York. He stated that there have been few changes in operating procedure since the installation of the high pressure units two years ago. The usual troubles, of course, have developed

The annual dinner of the A. S. M. E. at the Bellevue-Stratford in Philadelphia required facilities exceeding those of the main Ball Room

Warren H. McBryde, President of A. S. M. E. for 1940, is a consulting engineer and industrialist of San Francisco, Cal.

due to slagging of gas passages and furnace walls, water circulation trouble, cleaning of air preheaters and other details, but such changes as have occurred have dealt mainly with the method of makeup, the method of watching water levels, chemical feed, sampling of boiler water, and the taking of steam samples.

Experiences at Fisk Station in Chicago were related by A. E. Grunert who stated that adjustments and changes have been necessary in turbine details to improve operation and blading performance. Difficulties were also encountered in the operation of the steam generators with furnace performance, water circulation, joint tightness, and steam purity which have required changes for adequate solution. The records of availability indicate that the efforts toward improvements have been sufficiently successful to regard regular boiler-operating periods of six or more months' duration as a reasonable expectancy. Turbine availability in the topping installation has exceeded this performance in previous operation.

At Logan Station of the Appalachian Electric Power Co., as reported by Philip Sporn, the availability of the 40,000-kw. topping unit was 97.2 per cent and 84.7 per cent for the boiler during the last 13 mo. It is thought, therefore, that the plant is practically through with the initiation period and is now functioning on a routine basis. At the time of its purchase in 1935, the 40,000-kw. turbogenerator was the largest-capacity, 3600 r.p.m. topping turbine unit that could be proposed and the first hydrogen cooled generator placed on order. It is also, so far as is known, the only water-cooled generator stator. The boiler is still the largest built to date, 1,000,000 lb. per hr. at 1250 lb. per sq. in. pressure, 925 deg. F. steam.

With an availability record of 94 per cent since last overhauled, 7300 hr., the 10,000 kw., 1200-lb. superposed turbine in the Omaha Steam Electric Station, as reported by Louis Elliott, its reliability is considered as substantially on a par with that of the 325-lb. section of the plant.

Presenting a method for comparing steam boiler performance, E. G. Bailey described how direct measurement of evaporation was accomplished in France in 1874 and compared it with recent data on modern furnaces using the gas-temperature-weight method. A method of comparing data from all types, kinds, and sizes of boiler units at diverse rates of output, which was described, consists of plotting "heat absorbed" in per cent of total heat available against "equivalent surface area," which results in all points, having the same B.t.u. available per sq. ft. per hr., being on the same ordinate.

It is very desirable, he stated, to know the actual rates of heat absorption in different elements of a boiler unit for the purpose of comparing effects of different rates of operation, different values of excess air, kinds of fuel, ash and slag behavior, and kinds of heat-absorbing surface. The direct method of measuring heat absorption by evaporation calls for segregation of heat-absorbing surface which is either very difficult or entirely impossible, due to boiler construction and interference with circulation. The heat absorbed in some parts of a boiler unit may readily be determined by the direct method, such as in the case of superheaters, some economizers, and air heaters. A second method is possible, wherein the heat absorbed in a section of the boiler unit, such as the furnace or a tube bank, results from calculation using average gas temperatures and gas weights entering and leaving the section, the difference, allowing for any combustion of fuel taking place within the zone being measured, being the heat absorbed.

Fuels

"Obtaining fuel to satisfy the requirements of modern power plant equipment," said R. G. Rincliffe in his paper on Modern Coal Purchasing, "requires familiarity with methods of combustion and production of coal. The complexities of present-day plant operation and coal-mining practice makes it impractical for the coal buyer to aspire to a complete knowledge of such matters, and his ability to purchase coal successfully must, therefore, depend on the reliability and completeness of the information supplied him by the operating group in connection with conversion of the coal, and by the field engineer on conditions at the mines."

Advantages and disadvantages of spot purchases and purchase on contract were given and the author expressed the opinion that it is sound business to pay prices that will guarantee sources of supply. The coal buyer is the agent of the operating engineer to procure the most economical fuels for each type of equipment. To this end, a frank exchange of information will provide an effective approach to this complex problem.

The comparative economy of generating steam with anthracite, bituminous coal and fuel oil for industrial plants in the New York area was discussed by Gusta A. Anbro, using factual data he had gathered and presented in the form of tables and curves. His comments centered around the topics: cost of fuel, effect of fuel on plant efficiency, effect of fuel on steam and power consumption, effect of fuel on repair material costs, effect of fuel on labor requirements, refuse disposal,

and investment in changes and new equipment. "If an investment in fuel-burning equipment is contemplated," he said, "the consideration of fuel cost will involve some judgment on the probable and possible future price trends.

"Past history is generally helpful in this connection. . . . The difference in efficiency that may be expected with different fuels and firing methods is the subject of much misconception, misrepresentation and controversy."

Dealing with the installation, operation and maintenance of cloth filters for handling ventilated air from pulverized-coal mills, A. R. Mumford, A. A. Markson and T. Ravese related their experiences in solving problems in connection with the cloth-bag filter system as used at the Kips Bay Station in New York.

In defining equitable limits of dust emission from stacks, P. H. Hardie warned that although he was dealing mainly with the problems of control and industrial plants, it should be recognized that some form of control must be extended to the small coal consumer if we wish to attain considerably higher freedom from dust in the air. Surveys show that the multitude of small users of solid fuel are more responsible for air pollution than the few large consumers.

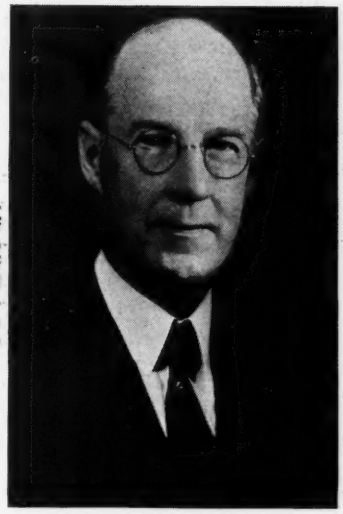
Engineers seem agreed that there should be some limit as to the amount of flue dust a plant is permitted to discharge into the atmosphere but there is no exact mathematical answer to this question. This whole problem is being investigated by a subcommittee of the Power Test Codes Committee whose duty it is to draft a test code for dust-separating apparatus.

Governors and System Regulation

Increasing complexity of interconnection requirements has brought to the foreground of thought the subject of steam-turbine governors. Attempts have recently been made to draft specifications for governing equipment that might be applicable both to steam and hydraulic prime movers, and Reed J. Caughey indicated that the purpose of his paper on Steam Turbine Governors was to state the essential characteristics, functions, and behavior of governing apparatus both for condensing and superposed turbines.

While the governing requirements for steam-turbine generators, in regard to stability and safety of operation, can generally be determined by the manufacturer, the characteristics of turbine-governing mechanisms to suit them best to the particular requirements of a purchaser's system and load usually cannot be so readily determined by a manufacturer. In addition the effect of turbine-governing characteristics on power-system stability is a controversial matter and warrants more investigation.

To develop the effect of these relations, Mr. Caughey discussed general principles of governing; governors and their limitations as speed indicators; governing mechanisms and their limitations, due to regulation and rapidity of load changes; protection of the steam turbine against overspeeding. In addition, a short description of the governing problems encountered in the design of superposed steam turbines is included with a tentative specification for steam-turbine-governing mechanisms.



Alexander G. Christie retires from the presidency of the A. S. M. E. leaving the society with a long list of very active professional committees, a substantial increase in membership and a comfortable balance in the treasury

Constant System Speed and the Steam-Turbine Governor was the subject of a paper by A. F. Schwendner in which the effects governors and governing valves have in maintaining or disturbing the system speed were discussed. It was pointed out that, when the governor characteristics of all units in a power-generating system are known, the combination of units used for certain load blocks can be determined not only for the best generating economy but also for better system speed.

From the manufacturer's point of view, it was stated, a governor is good if it satisfies the customer's requirements. The introduction of the superposed turbines and the larger-capacity 3600-r.p.m. units brought a new type of steam-turbine generating unit into the power systems. The small rotor inertia and consequent high rate of acceleration inherent in this type of unit require fast and sensitive governors so that the units may be synchronized well. A sensitive governor which follows the smallest changes in frequency does not have a smooth steam-flow chart. If a unit with a sensitive governor is put on the line with a unit which has a sluggish governor, the steam-flow changes shown on a recording meter will increase, and will increase further with the additions of other units with sluggish governors.

On the generator end of the discussion of system operation, Sherwin H. Wright was of the opinion that in an interconnected power system the frequency regulation and tie-line power swings are influenced by the electrical characteristics of all electric equipment connected to the system, including generators, lines, and miscellaneous motors, as well as by the mechanical characteristics of all rotating apparatus. In his paper the interrelated action of these factors was visualized by means of the mechanical analogy developed in connection with power-system stability, and this was augmented by a discussion of angular displacement with load and kinetic-energy values for typical machines, generator reactance, and short-circuit ratio.

Practices of the Philadelphia Electric Co. system in the regulation of system load and frequency, including the scheduling and actual operating capacity with regard to reliability and economy were described by Herbert Estrada and H. A. Dryar. The effect of changes in system load or generation on frequency, the self-regulation characteristic of the system, and the combined system governor action were discussed from the standpoint of the individual and the interconnected group of systems. The practices of the interconnection in manually regulating the frequency and the incident problems thereto were considered.

In summarizing the results of their studies, the authors came to the following conclusions: 1. The sensitivity of the governors should be increased as much as possible; 2. The instantaneous speed regulation of the governors over the entire load range should be more uniform; 3. The average speed regulation of the governor should be reduced as much as possible without, however, sacrificing stability of parallel operation; 4. Where tie-line loads must be regulated, the regulation of frequency or tie-line loading is a mutual operation, requiring the cooperation of all system dispatchers. The regulation of the frequency must be performed with regard to the tie-line loading and the regulation of the tie-line loading must be performed with regard to the frequency; 5. Where interconnection tie lines require no regulation, frequency variations will indicate a change in system load and the interconnection dispatcher can allocate the load change on the basis of economical loading.

Illustrations of normal operating experience with regard to speed regulation in several of the systems of the Hydro-Electric Power Commission of Ontario, in which the results obtained vary greatly, were submitted by Otto Holden. He described operating conditions on four widely varying power systems. In one case, the means, adopted to reduce the wide variation in frequency of a small system serving two mines only, were discussed. The problems encountered in larger systems serving mines, paper mills, grain elevators, and municipal requirements were dealt with, concluding with the largest of the four, a system developing 1,400,000 hp. at peak load, fed from nine generating stations.

Power swings chargeable to hydraulic turbines, their characteristics, source and elimination were discussed by W. J. Rheingans who supplied technical data on the subject and showed that power swings are due to draft-tube surges. Further conclusions of his studies were that the power swings are produced by fluctuations in torque on the runner, which in turn are caused by the draft-tube surges and penstock-pressure fluctuations; that the magnitude of the power swings depends upon the magnitude of the change in torque on the runner and upon the relation between the frequency of the draft-tube surges and the natural frequency of the generator connected to the distribution system; that by avoiding resonance of draft-tube surges and natural vibrations in the generator during design of a proposed hydroelectric unit, serious power swings can be avoided; that power swings as much as 10 per cent of the rated output of the generating unit can be tolerated without harm to the operation of the unit or stability of the transmission system; that the power swings can be greatly reduced or eliminated in the field by admission of air to the draft tube or by making physical changes in the draft tube.

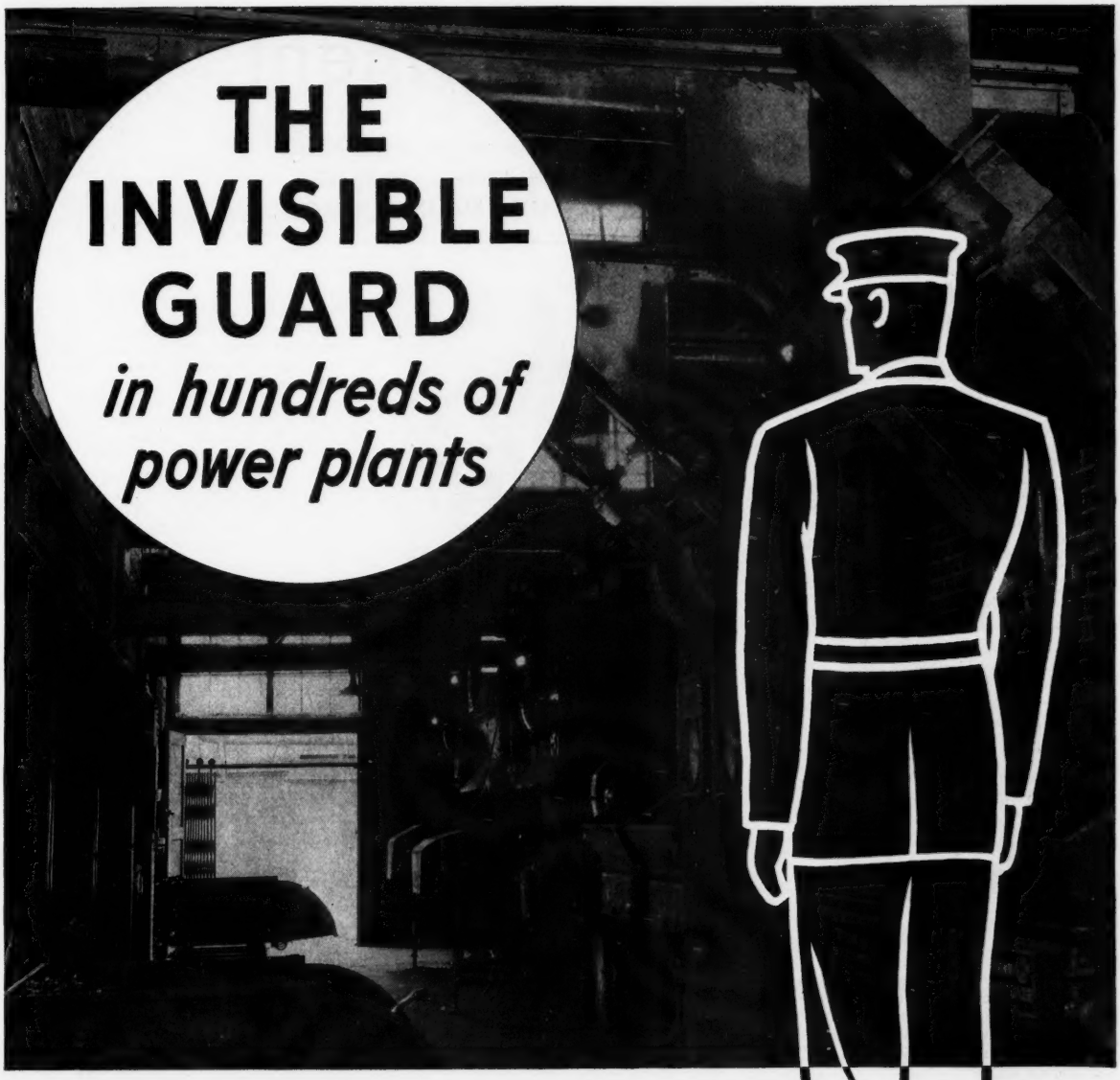
Piping Design

One whole session was given over to a paper prepared by D. B. Rossheim and A. R. C. Markl for the discussion of basic problems, on which, it was thought, agreement must be reached in order to establish a satisfactory working-stress basis for pipe lines. It was stated that during the last decade, economic considerations and new processes in the power, oil-refinery, and chemical industries have produced a trend toward large-scale units and high operating temperatures and pressures. With the attendant increase in line sizes and wall thicknesses, the subdivision of pipe lines into convenient runs with expansion bends soon proved entirely inadequate; instead, today most piping for severe service is carefully analyzed for forces and stresses, full advantage being taken of the inherent flexibility by minimizing the number of anchors, guides, or other restraints. A natural consequence of this improved accuracy in evaluating thermal effects is the necessity for a review of stress limitations as they apply to expansion stresses alone and in combination with internal pressure. The paper was presented and discussion took place around the following topics: 1. Proper allowable stresses for combined pressure and expansion effects; 2. Influence of and limits for localized stresses under static and repeated loading, such as in bends and corrugated pipe; 3. Capacity of bolted joints to withstand expansion effects without leakage or damage to flanges, bolts, or gaskets; 4. Effect of prespringing, self-springing, creep, and yielding on operating and off-stream stresses.

Bearings and Lubrication

Bearings made of plastic materials can be used successfully, said L. M. Tichvensky, not only for the case of perfect fluid lubrication but also for that of semi-fluid lubrication. Certain additions, such as graphite, will sometimes permit the application of these materials under conditions of dry friction. Heavy-duty plastic bearings are being used in the steel mill industry. Lubricated and cooled with water, they carry heavy loads at pressures of several thousand pounds per square inch. Oil, water and grease are used extensively as lubricants for plastic bearings in industrial, marine and farm machinery.

In another paper, presented by Sydney J. Needs, a report was given of the results of a four-year study of thin films of vegetable and mineral oils. Aside from the problems of filtration, selection of the proper metal for the test surfaces and the preparation of the surfaces, the experimental work divided itself into two distinct parts. Part I described attempts to discover indications of increasing viscosity in thin films of oil formed by two plane disks approaching each other under loads of the order of 0.20 lb. per sq. in. with no tangential motion. Part II described experiments with plane surfaces approaching under loads up to 800 lb. per sq. in. with continuous relative rotation of surfaces. It also described a method of measuring the minimum film thickness reached under these conditions.



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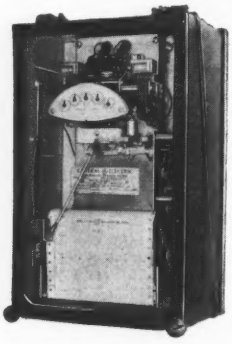
Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico,* should be addressed to Alfloc Ltd., Bush House, Aldwych, London, W.C. 2, Eng. Canadian inquiries should be sent to Aluminate Chemicals Ltd., 372 Bay St., Toronto, Ont.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Strip-Chart Recording Demand Meter

A NEW CONTACT-OPERATED, strip-chart recording demand meter has been announced by the General Electric Company. Combining a two-circuit totalizing relay and a recording demand meter, the new instrument (Type BR-1) may be employed for single circuit demand metering or for totalizing the demands of two circuits. In combination with totalizers or totalizing relays it may also be used to record the totalized demand of any number of circuits.



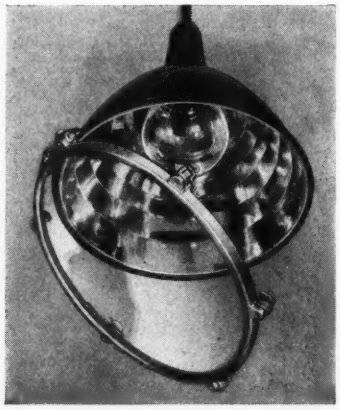
Instead of the conventional plunger, coil, and ratchet arrangement the meter is actuated by Telechron motors controlled by three-wire contacts. It is suitable for a wide range of load demands and provides a continuous record of at least one month's operation on a chart six inches wide.

"Steelite" Armor-Clad Lighting Unit

A HEAVY-DUTY, extremely rugged lighting unit particularly designed for heavy industry's severest service conditions, the new Benjamin "Steelite" is completely armor-clad with a steel housing above and "Herculite" heat, cold and impact resistant glass below.

The "Herculite" glass cover is absolutely unaffected by extreme temperature changes and is impact resistant to a remarkable degree—a one and one-half pound steel ball can be dropped from a height of 7 feet without breaking or shattering the glass. As an added safety feature, should the glass be broken, it disintegrates into tiny, blunt fragments and not into dangerous splinters. The glass is sealed into a special-formula, non-hardening gasket which seats against the reflector housing.

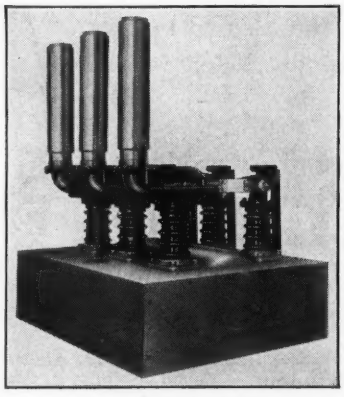
Two types of Alzak aluminum reflectors are available: one highly polished, specular type for high mounting installations; the other etched surface,



spread-type distribution for medium mounting heights. Both reflectors have exclusive multi-conical-section contour for most exacting light control. A unit for widespread light distribution is available; a change in the lamp position widens light distribution for low mounting. Reflectors are removable, being held in the housing by three screws. Benjamin "Steelite" units take lamps from 750 to 1500-watts. All parts are corrosion-resistant, conduit fitting and glass cover frame are aluminum. Socket is heavy porcelain enamel, with finger-type lamp grip. Benjamin Electric Mfg. Co., Des Plaines, Ill.

Air Blast Circuit Breaker

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., announces a new oilless circuit breaker, designated as type AB-15-500 and rated 600 to 1200 amp. at 15 kv. with 23 kv. insulation and interrupting capacity rating of 500,000 kv-a. It consists essentially of an air storage tank containing compressed air, a main air blast valve, three interrupting chambers mounted upon hollow insu-

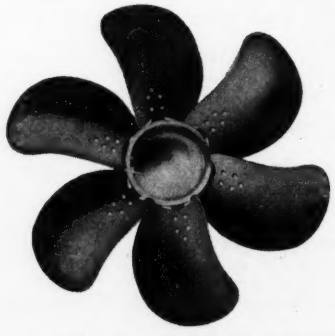


lator supports, three exhaust mufflers or coolers integrally mounted with the interrupting chambers, and isolating contacts connected in series with the interrupting chambers, also mounted on insulator supports.

Each interrupting chamber has a hollow stationary contact forming a port or entrance to the muffler. The movable contact in making contact with the stationary contact closes the port and is normally held in this position by heavy springs. The interrupting process is initiated by admitting compressed air to the interrupting chamber through the air blast valve. The compressed air operating against a piston attached to the movable contact causes the contacts to separate, thereby providing an outlet through which the compressed air escapes into the cooling chamber. As the contacts separate, an arc is drawn, which is immediately enveloped and centralized by the action of the air blast. Extension and centralization of the arc automatically connects a resistor in parallel with a portion of the arc, thereby eliminating high frequency transients and reducing the rate of rise of recovery voltage.

Six Blade Fan Assembly

THIS fan blade made by William J. Lohman, Inc., 62 Ninth Ave., New York, N. Y., is especially constructed for use in fan assemblies where extra heavy duty is required. The 41 degree pitch in the blade allows it to deliver large volumes of air at very slow speed thereby reducing all the air noises. Die stamped, die formed steel blades are riveted to die formed steel spiders which are in turn bolted to cast iron



hubs. Made from stampings and forming dies throughout making every part that goes into the assembly perfectly matched, then they are all weighed separately before they are assembled. There is no filing in or drilling out to make them balanced. The six blade assembly, which is new, will be made in 30, 36, 42, 48, 54, 60 and 72 in., all with 1 in. bore for 1 in. shafts.

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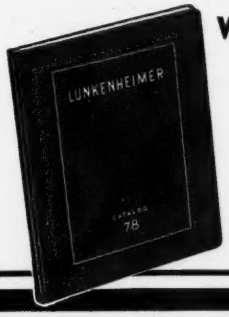
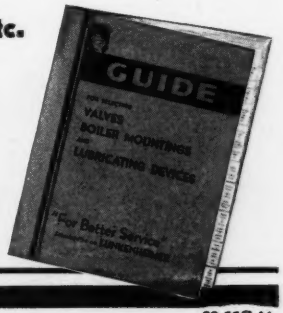


Whistles, Cocks, Fittings, Unions, Air Nozzles, Etc.

Lunkenheimer Catalog 78 describes and lists the complete Lunkenheimer line. The Guide is a ready reference for selecting Valves, Boiler Mountings and Lubricating Devices in which products are grouped by pressure, type and use. Ask your local Lunkenheimer distributor for copies or write us direct.

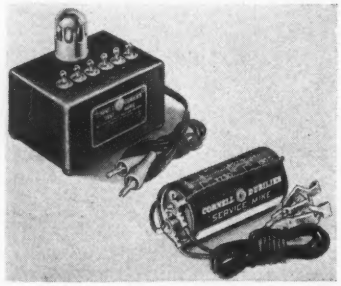


THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

28-55C-44

Motor-Start Capacitor Servicers

THE NEW test instruments announced by Cornell-Dubilier Electric Corp., South Plainfield, N. J., simplify the proceedings involved in the replacement of capacitors in motor-starting circuits. The Test-Mike is a multiple-capacitor unit of the a.c. electrolytic type, with six toggle switches which in different position com-



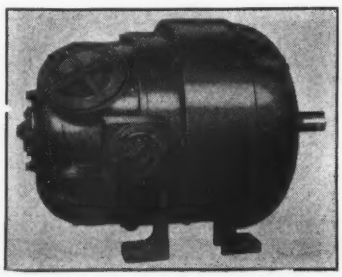
binations provide twelve capacity values ranging from 18.75 to 150 m.f.d. In addition it includes a pilot lamp for checking operation of the mechanism which cuts out the starting capacitor when running speed has been reached. This instrument is enclosed in a case 3½ by 5 by 3 in. The Service-Mike gains even greater compactness through the elimination of the case, switches and pilot lamp. It provides the same capacity range as the Test-Mike but the twelve variations are obtained through different interconnections of its four terminals. It is cylindrical in shape with a diameter of $1\frac{13}{16}$ in. and overall length of 3⅞ in.

Explosion-Proof D.C. Motors

THE RELIANCE Electric & Engineering Co., Cleveland, Ohio, is now prepared to build explosion-proof direct current motors as large as 75 hp. The enclosed, fan-cooled design, with ball bearings, has been developed by Reliance in the smaller sizes from 1 hp. up over a period of years.

Recent changes and improvements over the original design now make it possible to provide a complete range of sizes from 1 hp. up to 75 hp., all of them tested and approved by the Underwriters' Laboratories, Inc., for Class 1 Group D hazardous locations.

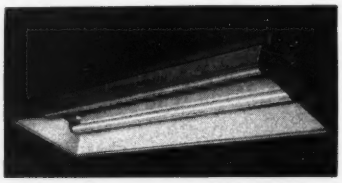
The motors are designed to operate safely in places made dangerous by the presence of gases and vapors such as are produced by methane, acetone, benzene, the various alcohols, common pyroxylin solvents, and the vapors of various petroleum distillates, including gasoline.



Basic requirements for motors to operate safely in such locations is that if gas or dust inside the motor enclosure should become ignited, the resulting flame is prevented from escaping to the outside air. At the same time the motor enclosure must have ample strength to withstand, without bursting or loosening of joints, the highest internal pressure which might develop in the event of an explosion of gases such as those present about the motor. Finally, the construction of the motor must be such that in the event of a burnout, the motor enclosure will not reach a temperature sufficient to cause surrounding vapors to ignite.

Fluorescent Lamp Fixture

A NEW porcelain enamel single-reflector type twin-lamp unit designed particularly to make available the advantages of fluorescent lighting, to general overhead illumination of industrial interiors. This is practicable now for the first time due to the higher light output of the new 48-inch, 40-watt lamps. The new Benjamin "Stream-Liter" Fluorescent lamp units have a wide spread distribution of light comparable to dome-type incandescent lamp reflectors long used for general industrial lighting. The deep shape of this fluorescent lamp reflector provides adequate shielding (the cutoff angle being 72½ degrees to the middle of the far lamp) while the combination of unexcelled diffusive properties of the porcelain enamel reflector and the low surface brightness of the lamps provides unusually soft, glareless lighting.



Benjamin "Stream-Liter" units are twin lamp fixtures utilizing a single, large-area porcelain enamel reflector common to both lamps. Reflector has closed ends to provide additional shielding. Lamps, sockets, thermal glow-switch type starters and line ballast equipment for regulating current to the lamps are all attached to the reflector which is hinged to the upper housing of the fixture for greater accessability. In installation the upper housing can be hung in place and the reflector suspended underneath on its hinges while connecting line leads. Suspension is by means of chandelier chain to hooks provided on top of housing or by rigid conduit secured through knock-outs in housing by locknuts.

"Tulamp" type ballast units, which incorporate a capacitor in one lamp circuit to bring power factor to approximate unity, are used in these fixtures. These ballast units also operate the lamps far enough out of phase to reduce inherent alternating current flicker to a point where it is no longer objectionable. One socket of each lamp is equipped with the new replaceable cartridge type thermal glow-switch starter. Benjamin Electric Mfg. Co., Des Plaines, Ill.

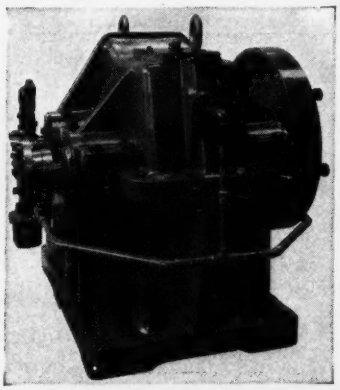
500 or 1000 Watts Resistor

HERE IS one of the big Resistors recently introduced by the Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill., It is 12 in. long, 2½ in. in diameter, and is rated at 500 watts. But it is second in size to the 2½ in. x 20 in. 1000 Watt Ohmite resistor, the largest vitreous-enameled porcelain resistor made.

The resistance wire is accurately, uniformly wound on a porcelain core. Special Ohmite Vitreous Enamel permanently locks, insulates and protects each turn of wire on the porcelain core —prevents shorts, efficiently conducts away generated heat, insures continuous trouble-free service. The resistance wire is both mechanically locked and brazed to the terminal lugs to assure good contact at all times.

Speed Increaser

A NEW line of speed increasers for operating centrifugal pumps, high-speed blowers, and compressors, and for pipeline service, has been announced by the Westinghouse Electric & Mfg. Co. Standard gear ratios vary from 2 to 1 to 12 to 1, and these new units are available in ratings of from one horsepower per 1000 r.p.m. of the high-speed shaft to more than 1800 horsepower per 1000 r.p.m.



Speed increasers can be supplied for either right- or left-hand assembly. Sleeve bearings have been designed to provide low unit pressures and assure permanent alinment with minimum friction loss. Lubrication is accomplished by a self-contained circulating oil system, including a circulating pump, an oil cooler, strainer, relief valve, and sight flow indicator. Gears are spray-lubricated at the line of contact; all bearings are under pressure lubrication. Frames are split horizontally to permit easy access to all internal parts, and each unit has an easily removable inspection plate. Average efficiency of these units is better than 96 per cent.

Prevent scale troubles-the DEARBORN WAY

Scale in your feedwater system is a source of trouble and expense. It fills up feed lines—clogs injectors, feed pumps, check valves, and feedwater heaters. Removing this scale is a costly, troublesome operation.

You can prevent scale deposits in your pumps and feed lines and other feeding equipment with Dearborn Water Treatment. The sodium hexametaphosphate and organic reagents in Dearborn Treatment act chemically to prevent precipitation. What's more, Dearborn Treatment will disintegrate any scale already present. Dearborn formulas are also balanced to give full protection against pitting and corrosion, as well as to reduce the possibility of steam contamination.

Let Dearborn engineers make a thorough analysis of your plant. They will recommend treatment balanced to fit your individual requirements, set up a systematic test procedure, and make frequent check-ups to see that you are getting satisfactory operation. Write,

Dearborn Chemical Company
Dept. F, 310 S. Michigan Ave.
Chicago

Most Modern Scientific Methods Used in Dearborn Laboratories

A highly trained laboratory and research staff, using the most modern equipment and methods, forms the foundation of Dearborn Service. By making a thorough water analysis and a detailed study of operating conditions, Dearborn can recommend a water treatment balanced to meet the needs of each individual plant.

Dearborn

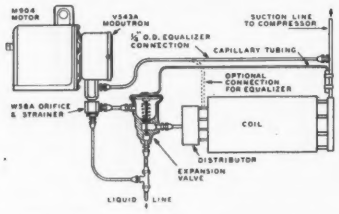
TRADE MARK REGISTERED

WATER TREATMENTS AND CHEMICALS FOR INDUSTRY

CHICAGO • NEW YORK • LOS ANGELES • TORONTO AND PRINCIPAL CITIES

Air Conditioning Control

MINNEAPOLIS-HONEYWELL REGULATOR Co., Minneapolis, Minn., has developed the Modutron system to provide an exceedingly simple arrangement for securing the proper modulation of the liquid flow in direct expansion air contioning systems to give optimum comfort results from the point of view of both temperature and relative humidity.



The Modutron System may be applied to any refrigeration installation employing thermostatic expansion valves with the usual external equalizer. Since usually only the equalizer line need be disturbed when installing the Modutron, it may be added to existing systems for modernization as easily as it may be installed on new work.

A small electrically operated valve, known as the V543 Modutron, is installed in the equalizer line of the thermostatic expansion valve. The electric motor, which operates the valve, is modulated by temperature, humidity, pressure of any other conditions to be controlled. It opens the valve wide when maximum cooling is required and if less refrigerating effect is required, the electric motor moves the valve to a more closed position, reducing the effect of the external equalizer on the expansion valve.

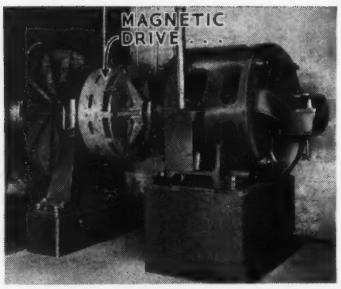
Insulating Firebrick

A NEW insulating firebrick made of special Georgia kaolin by an exclusive process, designated K-16, is announced by The Babcock & Wilcox Co., 85 Liberty St., New York, N. Y. Representing a radical improvement in heat-insulating materials, K-16's now make available for the first time a product that has the stability of a fired-clay refractory and yet weighs less, the average weight being only 1.1 lb. per 9 in. straight or approximately 19 lb. per cu. ft. These insulating firebrick retain their structure, show negligible shrinkage and can withstand loading without deformation at temperatures up to 1600 deg. F. for direct exposure and 2000 deg. F. (interface) for backing up.

Magnetic Drive

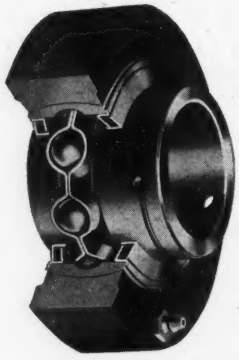
A NOVEL, variable-speed drive method, using electromagnetic principles for torque transmission, has been developed by Electric Machinery Mfg. Co., Minneapolis, Minn. The magnetic drive, as it is called, is a rotating device to provide controllable, variable speed and is particularly suited to boiler draft fans which require an accurately controllable wide range of variable speed, and to centrifugal pumps.

It consists of two simple, compact rotating parts, a flux linkage ring, or ring, and a magnetic flux producer, or magnet. The ring is driven by the driving motor. The magnet revolves within the ring and drives the load shaft. There is no mechanical torque connection between ring and magnet. The torque is transmitted by electromagnetic forces only, through an air-gap which separates ring and magnet. The torque transmitted by the magnetic drive, and hence the speed of the load shaft, is dependent on the magnetic flux in the air-gap. This magnetic flux is varied by adjusting with a rheostat, the small control current to the magnet.



Ball Bearing Unit

STEPHENS-ADAMSON MFG. CO., Aurora, Ill., announces the addition of self-aligning Sealmaster Ball Bearing Cartridge Units to their Sealmaster bearing line. The cartridge units feature the same advanced design as other Sealmaster units. The patented centrifugal labyrinth seal effectively



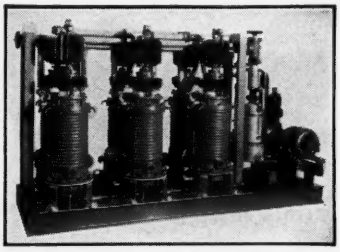
seals bearing from all foreign materials in the atmosphere and retains the lubricant. Mis-alignment of the shaft cannot interfere with the effectiveness of the seal, for the outer race is ground on radius and locked in ground housing socket with locking nipple which permits 2 to 4 deg. mis-alignment in any direction. Wear or glazing is said to be positively avoided as they are assembled without pressure.

Turbine Well Pump

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., announces a new line of turbine well pumps which feature vacuum molded impellers. The smoothness of the blade surfaces and uniformity of the castings result in high efficiency and greater certainty of performance. Wear or abrasion in the impellers is reduced to a very negligible minimum by the use of hard, high-tensile bronze. Available with either enclosed oil-lubricated or open water-lubricated shaft bearings, these new turbine well pumps are readily adaptable to individual local conditions.

Excitron Rectifier

THE ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., announces a single-anode power rectifier designated as the Excitron type. Instead of having all the anodes in one vacuum chamber, the Excitron consists of factory-assembled groups of relatively small vacuum tanks, each containing a single anode



and its individual cathode. The tanks, which are externally cooled by water, are generally mounted in groups of six on a heavy structural steel frame. This frame also supports the vacuum pumping equipment which is connected to the tanks through a vacuum pipe manifold. The arc ignitron and control equipment is also mounted and wired on this frame.

Acid Resisting Pump

DESIGNED for evaporative coolers and chemical laboratories, a new pump, made of stainless steel and mounted on a vitrus enamel porcelain stand, has been developed by the Air-O-Line Co., Dallas, Texas. It is equipped with

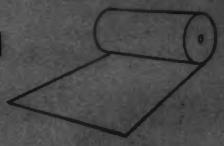
a new motor fan which pulls the air up through the motor substantially reducing the motor temperature. All bearings are self-alining Oilite mounted in a sealed oil compartment on brackets separate from the end bells. To prevent corrosion, the tube outlet is made of pure copper plated with block tin inside and out. This pump is made in three sizes ranging from 140 to 360 g.p.h.

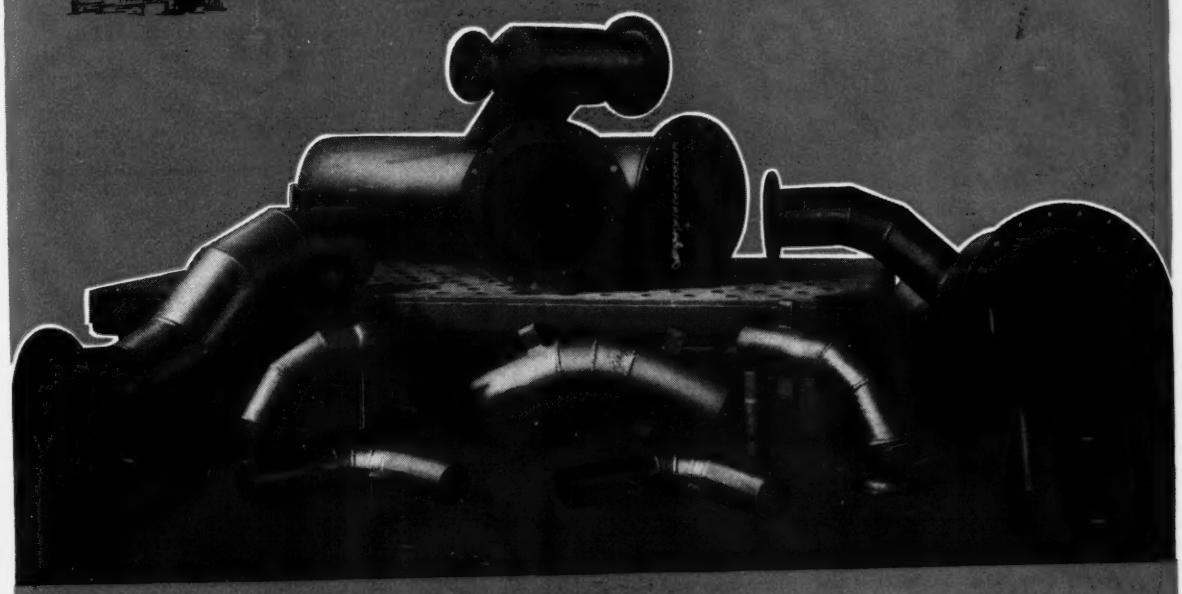
FOR THE BODIES of its blow-down valves used in Nalco systems, the National Aluminate Co. has adopted, after long investigation, a nickel alloy cast iron, because of close-grained structure, ready machine ability and tensile strength of 47,000 to 52,000 lb. sq. in. Composition of the alloy is, carbon 3.2 per cent, silicon 1.5 per cent, manganese 0.8 per cent, nickel 1.25 per cent, molybdenum 0.4 per cent. For valve seats, K Monel metal is used to resist abrasion and corrosion.

Paper Manufacturer Cuts Time

BETWEEN

INVESTMENT AND RETURN





To construct and weld these complicated parts of power and process lines *in the field* would have been a long, arduous job.

This paper manufacturer wanted *results*, so his engineers turned to Grinnell for accurate sub-assemblies, prefabricated to their specifications, as soon as the job was started. When the time came for their use, these units were ready to slip into place and weld.

Advanced plant facilities, strategically located for service to the nation . . . piping experts who can interpret your plans in terms of latest developments . . . qualified welders, whose work passes insurance tests before it leaves the plant . . . these are some of the benefits you gain when you say, "Give the plans to Grinnell." Grinnell Co., Inc., Executive Offices, Providence, R. I. Branch offices in principal cities of the United States and Canada.

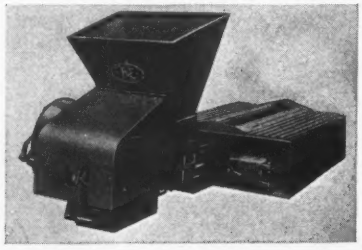
PREFABRICATION BY **GRINNELL**

WHENEVER **PIPING** IS INVOLVED

Small Commercial Stokers

THE FLYNN & EMRICH CO., Baltimore, Md., is now in production on the new F & E Series 40 Underfeed Stoker, built primarily for heating boilers rated between 25 and 100 hp. It is adaptable to either bituminous or anthracite coal, the anthracite model carrying approval of the Anthracite Industries Laboratory.

Many of the engineering features of the larger F & E Underfeed Stokers are incorporated in the Series 40, such as a ram feed powered by the F & E Unit



Type Electro Hydraulic Drive with only three moving parts. It has synchronized coal feed and air control to insure proper carburetion at all times and at all coal feeding rates. Outside regulation of the fuel bed while the fire is burning is possible with the fuel bed regulator in event of a change in size or quality of coal.

The mechanism and the ram are protected from damage by foreign matter such as railroad spikes and tramp iron in the coal, by the ram safety feature, a method that completely stops operation of the ram and permits removal of the obstruction through a door in the ram case. A new feature, the removable ram case liner, provides an opportunity to replace, at low cost and with minimum effort, a part that is subject to most wear. Completely automatic controls are furnished as standard equipment, with a few special controls available at additional cost. A bin feed device can be furnished for both stokers at additional cost.

Pyranol Capacitors for Industrial Use

FOR POWER-FACTOR improvement in industrial plants General Electric offers a group of new Pyranol capacitor equipments, designed to be mounted either on a platform, on the floor, or suspended from the ceiling. The new capacitor equipment, Class DTSR, is built of all-welded sheet steel, which makes it a strong, rigid rack of smooth, pleasing appearance.

While the bodies of the capacitor units are exposed to a stream of ventilating air, the bushings, buses, and fuses are enclosed in a dust-tight compartment, eliminating any possible difficulties from dust and dirt accumulation. Conduit knockouts are provided on top and both

sides for ease in making connections. There are no external discharge resistors in these new units, as the resistors are built-in. All the fuse clips and fuse ferrules are silver-plated to eliminate oxidation.

Feet are provided on these capacitors for floor or bracket mounting and there are also eyes for lifting and suspension from the ceiling. Since most factories consider floor space as valuable, this feature is a distinct advantage. Switches may be mounted on pillars or walls when the units are suspended from the ceiling.

News from the Field

ON JANUARY 12 and 13 the fifth annual meeting of the Louisiana Engineering Society will be held at the St. Charles Hotel in New Orleans.

SCHEDULED for completion by Feb. 1, 1941, an addition to the Dresser Station of the Indiana Public Service Co. at Terre Haute, Ind., has just been started. The new 650 lb. section will consist of two B. & W. boilers and a 50,000 kw. G.E. turbo-generator unit. Sargent & Lundry, Inc., are engineers.

WORTHINGTON PUMP AND MACHINERY CORP. announces the election of Maynard D. Church as a Vice-President. He is also President of Moore Steam Turbine Corp., Wellsville, N. Y., which has been for some time a Worthington subsidiary and he will continue to be in charge of Moore operations. Upon his graduation from Syracuse University in 1906, Mr. Church joined the Kerr Turbine Co., of Wellsville, which he left in 1913 to become vice-president and chief engineer of Dayton Turbine Pump Co. From 1915 to 1924 he served as chief engineer of Terry Steam Turbine Co., and in 1924 became general manager of Moore Steam Turbine Corp. He was elected president later that year.

The election of R. W. Towne as assistant secretary of Worthington was also announced. A graduate of Cornell University, in 1924, Mr. Towne immediately joined the Moore organization, becoming secretary and assistant treasurer in 1936.

THE DEWOLF FURNACE CORP. announces the appointment of W. H. Davidson, 1600 Walnut St., Philadelphia, Pa., as representative for the southern portion of New Jersey, the eastern portion of Pennsylvania, and the states of Delaware and Maryland.

THE NATION'S newest and most modern wholesale food distribution center, Kansas City, Kans., Food Terminal, through which the produce of 40 states will pass, was opened for business December 4. The market, built as a P.W.A. project, will, when fully completed, cost approximately $4,000,000.

The largest unit in the project is the group of produce buildings, four structures, three one-story and a two-story building, all 450 ft. long and 98 ft. wide. Biggest of all the buildings at the market will be the cold storage plant, costing $641,000, scheduled for completion next spring.

Henry L. Doherty, founder and head of the Cities Service Co. died Dec. 26 at Temple University hospital, Philadelphia, of pneumonia. Mr. Doherty was born at Columbus, O. in 1870 and became an office boy for the Columbus Gas Co. at the age of 12 and worked there 8 yr. For the next 15 yr. he was chief engineer or manager for utilities in Wisconsin, Minnesota, Texas and Colorado. In 1905 he organized Henry L. Doherty & Co. and 5 yr. later the Cities Service Co. to take over the supervision of the utilities leaving the original firm to handle the banking and investment end.

JANUARY 15-19 has been announced as the date of the 1940 Annual Meeting of the S.A.E. by John A. C. Warner, general manager of the Society. The meeting's 20 technical sessions, the SAE Engineering Exhibit and the Annual Meeting Dinner are to be held at the Book-Cadillac Hotel, Detroit.

CONTRACTS for the design and construction of a 10,000 sq. ft. research and development laboratory for the Cummins Engine Co., Columbus, Indiana, have been awarded to The Austin Company, engineers and builders. This structure will be of welded rigid frame construction, planned to provide testing and engineering facilities for Diesel engines. Special metallurgical and chemical laboratories are also included in the structure. Forced ventilation will be provided throughout the structure, which is scheduled for completion shortly after the first of the year.

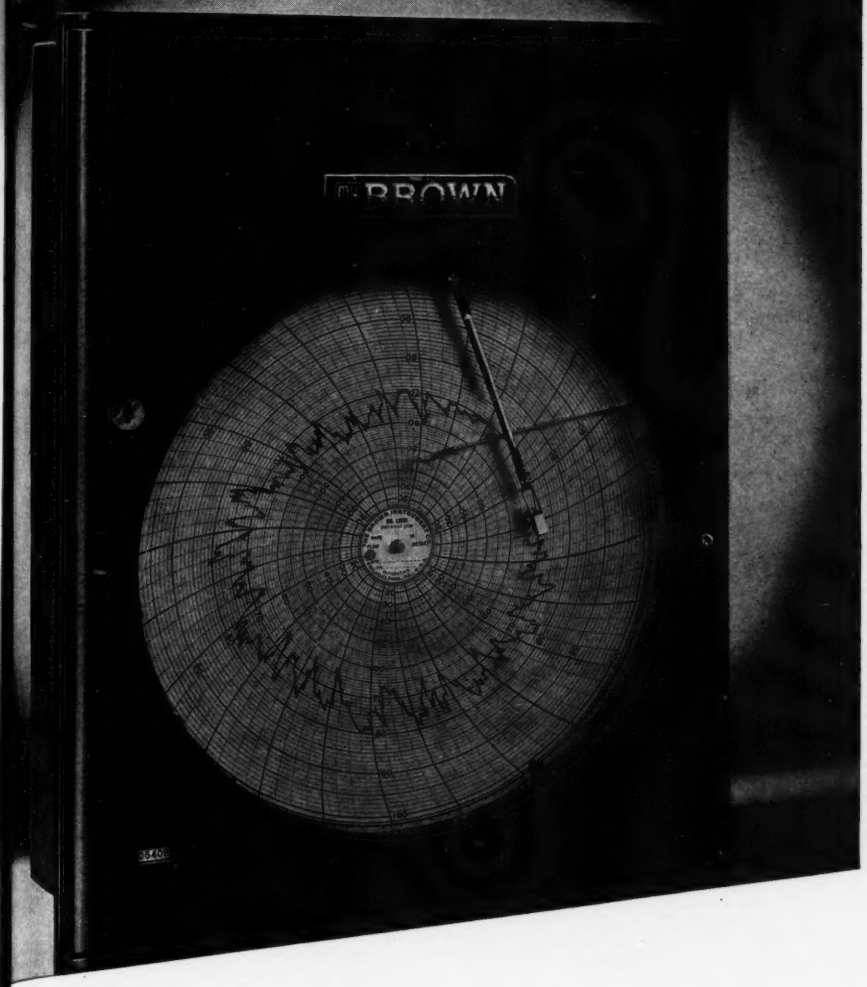
RALPH S. MACPHERRAN, Chief Chemist of Allis-Chalmers Mfg. Co. for many years and who only recently retired from active service because of a heart ailment, died November 13 at Duluth, where he had been visiting his brother. Identified with the iron and steel industry for nearly 50 years, he was especially noted as an outstanding metallurgist in the field of gray iron. In 1931 he was selected to receive the coveted J. H. Whiting gold medal award of the A. F. A.

GEORGE F. BERTRAND has become associated with the Sheffler-Gross Co. of Philadelphia as sales engineer after 15 yr. experience in design, construction, and testing of air conditioning systems for industrial and comfort applications.

PENNSYLVANIA WATER & POWER CO. has been authorized by Federal Power Commission to purchase the stock, franchises and electric facilities of the Susquehanna Transmission Co. and Pennsylvania Transmission Co. The former has a 7¾-mi., 66,000-v. line from Holtwood Station to the Pennsylvania-Maryland state line; the latter has two lines, 15 and 18 mi. at 220,000 v. from Safe Harbor to the same state line.

THE CENTRIFIX CORP., 3029 Prospect Avenue, Cleveland, Ohio, manufacturers of Centrifix Purifiers for steam, air and gases, has now appointed Sawyer-Massey, Ltd., of Hamilton, Ontario, as its exclusive Canadian manufacturers.

CONTRACT has been awarded to The H. K. Ferguson Co., for the design and construction of an office building at the Barberton, Ohio, plant of The Babcock & Wilcox Co. The building is two stories, 56x122 ft., of brick and steel to match existing structures, and is designed for future air conditioning.



You'll Like

1. THE AUTOMATIC PLANIMETER PEN RECORD which shows steam flow in volume units and the time at which it was produced or used in any part of the 24 hour period, enabling you to easily analyze the cost of steam production and distribution.
2. SIX INTER-RELATED RANGE TUBES with inter-related direct reading charts.
3. INTEGRATOR DIAL. Easy to read. Simple counter—plain figures. Read it like your automobile mileage indicator.
4. STREAMLINED CASE. Universal mounting provides the much-desired flush appearance.

Advanced Design—SIMPLIFIES METERING OF BOILER OUTPUT AND PROCESS STEAM

When the operating principle of a flow meter is fundamentally sound, and when it has a service record of dependable accuracy of more than ten years in hundreds of power plants throughout industry, it's a difficult job to improve its design and performance.

Yet, that is what Brown engineers have done with the new line of Brown Rectangular Case Flow and Liquid Level Meters. They have not only improved the appearance but have produced an instrument that is a Triumph of Accuracy and Simplicity . . . thus obtaining even better performance than that of previous design.

Available with either electrical or mechanically-operated meter bodies for the measurement and control of steam, air, oil, gas and other fluids.

The Brown Boiler Room Instrument Booklet describes where to use Brown Flow Meters. Write for a copy. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.,* 4491 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Toronto, Canada: 117 Peter Street . . . Amsterdam-C, Holland: Wijdesteeg 4 . . . England: Wadsworth Road, Perivale, Greenford, Middlesex . . . Stockholm, 16, Sweden: Nybrokajen, 7.

BROWN Flow Meters

Accurate Measurement with Simplicity

WHEELCO INSTRUMENTS CO. announces the appointment of the Rodgers Engineering Co., Dallas, Texas, as its representative for the North Texas territory.

ANNOUNCEMENT has been made by E. C. Sammons, President of the Stoker Manufacturers Association that the 1940 annual meeting of the Association will be held at the Homestead Hotel, Hot Springs, Virginia, on June 6 and 7. Mr. Sammons stated that the Association and many individual members are continuing to give serious study to the problem of securing a larger share of the new home building business. He said that the next regular quarterly meeting of the Association, which will be held in the spring of 1940, will concern itself largely with a continuation of discussions on this problem. It is probable that the regular quarterly session of the executives of the S.M.A. will be held in the early spring at Columbus, Ohio, where stoker manufacturers will confer with coal research officials on problems concerning the mechanical removal of bituminous ash and development of automatic coal-burning "packaged" heating units.

GEORGE B. WADLOW, Sales Manager of the Industrial Equipment Division of the Continental Roll & Steel Foundry Co., East Chicago, Ind., announced that as of January 1, 1940, the Stoker Sales Department office at 605 N. Michigan Avenue, Chicago, has been discontinued so as to consolidate activities at the main office at East Chicago. The personnel remains unchanged. A. F. Ericksen and L. A. Snider, in charge of stoker sales, and B. F. Bower, Engineering, were transferred and will make East Chicago their center of operations.

F. M. HAGEMAN last month resigned his position with Piqua Municipal Light Department to assume the superintendency of the light, power, water and sewage utilities of Tipp City, Ohio.

THE OHIO PUBLIC SERVICE CO. Tuesday announced plans for a $2,000,000 addition to its electric plant in Warren, O., to include a 60,000 h.p. high pressure boiler, a 35,000 kw. turbo generator and a bank of 45,000 kw. transformers. Mr. E. L. Franklin, president, said the expansion is made necessary by power demands of the Copperweld Steel Co. now erecting a $2,000,000 addition to its plant in Warren.

FRANKLIN INSTITUTE of the State of Pennsylvania has made its first award of the Vermilye Medal to Lewis H. Brown, president of the Johns-Manville Corp. at a dinner in Philadelphia on Tuesday, Nov. 14. Named after its donor, William M. Vermilye, vice-president of the National City Bank of New York, the medal was established to "stimulate, encourage and recognize outstanding contributions in the field of industrial management". Hereafter, it is to be awarded biennially or over a longer period of time.

GEORGE L. CROSBY, vice president and general sales manager of Roller-Smith Co., died suddenly at his home in Bethlehem, Pa., on December 2, 1939. Mr. Crosby was born at Brookhaven, Miss., in 1883 and attended Millsaps College (Miss.) and George Washington University. After several years' sales experience he established his own sales-engineering offices in 1905 at Cleveland under the firm name of Crosby, Craft & Co. In 1910 Mr. Crosby became affiliated with the Roller-Smith Co. as sales engineer and manager of the Pittsburgh (Pa.) offices. In 1912 he was transferred to the New York offices of the company. When the main office was moved from New York to Bethlehem, Pa., in February, 1939, Mr. Crosby moved to Bethlehem.

ANNOUNCEMENT has been made by H. H. Barnes, Jr., commercial vice president of the General Electric Company, that Robert A. Jones has been appointed district engineer of the New York district, effective January 1, 1940. W. S. Hill was named assistant district engineer.

Death of John F. G. Miller

JOHN F. G. MILLER, vice president of B. F. Sturtevant Co., Hyde Park, Boston, Massachusetts, 62 years of age, died suddenly on December 9th of a heart attack at his home in Brookline, Mass. Mr. Miller, a native of Johnston County, Indiana, was a graduate of Purdue University, Class of 1903, where he was a four letter man and captain of football, track and basketball teams.

He became associated with the B. F. Sturtevant Co. in 1933 as vice president in charge of Sales, Advertising and Sales Promotion. Prior to this he was vice president and general manager of the American Blower Corp., Detroit, Mich., and a member of its board of directors.

Power Plant Research Lab

INTERNATIONAL recognition accorded H. F. Johnstone, professor of chemical engineering at the University of Illinois for his research, especially in the flue gas field, is said to be largely responsible for the research laboratory facilities which will be provided in the new University power plant. The laboratory will be on the main floor and will, it is said, be unmatched in any other university power plant in the country. The new plant which will cost about $1,675,000 will soon be started. It will consist of a steel frame structure with a brick and stone exterior and will cover a ground area of about 115 by 100 ft., varying in height from 44 to 59 ft.

Union Electric Company to Expend $20,000,000 For Expansion

UNION ELECTRIC CO. of Missouri, Inc., Twelfth and Locust Streets, St. Louis, Mo., is arranging an appropriation of about $20,000,000 for expansion and betterments in electrical properties during 1940, and proposes to proceed with program early in that year. Preliminary plans are under way for new steam-electric generating plant at Venice, Ill., to be operated in conjunction with an existing station at that place. It is understood that initial plant will have a capacity of close to 50,000 kw., with equipment installation to include turbine-generator units and accessories, high-pressure boilers and auxiliaries. Work will include extensions in transmission lines for increased power supply for system. Company also plans installation of new boiler units and other equipment to improve operating efficiency at its steam-electric station on Ashley Street, as well as provide increased output.

Smoke control and abatement equipment will be installed in different power plants in connection with general improvements and installation of considerable auxiliary power equipment both in electrical and steam departments. Extensions will be made in transmission and distributing lines in company territory in Missouri and Illinois, as well as expansion in rural electric lines, power substations, switching stations, and other operating facilities.

North Dakota Has Sales Tax on Steam Heat

THE STATE of North Dakota is now enforcing its sales tax on steam heat, recently enacted. A 2 per cent sales tax is levied on all utility companies in the State operating steam heating service lines, including all metered steam systems for heating purposes.

Panama Canal Project to Cost $35,000,000

THE WAR DEPARTMENT, Washington, D. C., is arranging early call for bids on construction program for strengthening the defenses at Panama Canal, for which a total appropriation of $35,000,000 was provided by the 76th Congress. The major part of the project will comprise the erection of buildings and installation of utilities at Albrook Field, Corundu Military Reservation, Mount Hope Military Reservation, Howard Field, Fort Sheridan and Fort Kobbe, including power station and electrical facilities, power lines, substation units and other electrical installation, as well as pumping stations, pipe lines and other utilities for water and sewage service. The initial call for bids will involve work to an amount of about $23,000,000, with additional bids for construction totaling $12,000,000 at later date. It is proposed to reduce the usual 60-day period for advertising bids to 45 days in order to speed up the program.

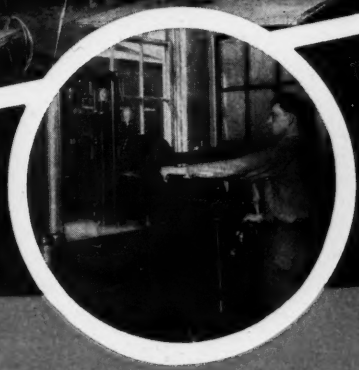
Alabama Power Co. Plans $6,000,000 Expenditure

ALABAMA POWER CO., Birmingham, Ala., is arranging a fund of about $6,000,000 for expansion and improvements in plants and system during 1940. A considerable part of the appropriation will be used at Mobile, Ala., where it is planned to expand existing steam-electric generating plant and install additional equipment for increased capacity; extensions also will be made in transmission and distributing lines in that area. This work, estimated to involve about $2,000,000, will be supplemented by an expenditure of $3,000,000 for line construction during the next 12 months, including transmission line extensions, and primary and secondary lines in rural areas, where considerable increased service will be arranged; also a portion of fund will be used for power substations and switching stations, and other field structures. Line improvements at Montgomery, Ala., and vicinity are estimated to cost about $350,000. At Mobile, the present power substation at Royal and St. Louis Streets will be modernized and enlarged, with installation of transformers, switchgear, etc., to cost about $250,000.

GOOD PIPING PRACTICE AND ECONOMY

POINT TO

PRE-FABRICATION



"PRE-FABRICATION" simply means that the piping is delivered to the job as a series of shop-built sub-assemblies . . . precision-made for rapid and economical field assembly. All possible fabricating is done in fabricator's shop by qualified operators working under the most favorable conditions with highly specialized equipment.

Obviously, qualified welders working with layout tables, form cutting machines, rotating fixtures, straightening tables, heat-treating and stress relieving equipment, etc., can produce *better* welding at lower cost. Certainly, inspection and test can be more searching and effective in the shop than in the field.

When piping is pre-fabricated, bends can be used where they will lower cost, add needed flexibility or simplify layout. Shop fabricated flanged joints insure proper facing and accurate alignment.

Shop fabricated and shop tested sub-assemblies shorten installation time and assure superior piping at minimum cost.

THE PIPE FABRICATION INSTITUTE

P.F.I. THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

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For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Combustion Equipment

Oil and Gas Burners. All types of John Zinc oil, gas and combination burners, for natural and forced draft in a size range from small domestic furnaces up to 25,000,000 B.t.u. per hr. per burner are covered in a new 50-pp. catalog in color. In addition to description and dimensions of the burner the bulletin contains data on installation, capacity curves, price lists and straightening vanes for gas, oil and steam lines. John Zinc Co.

Automatic Mechanical Draft Oil Burners, Designed for Domestic Installations is the title of a new pamphlet, Commercial Standard CS75-39, which was accepted by the industry as its standard of practice for new production beginning November 1, 1939. The price of the pamphlet is five cents and it may be had by writing to the Superintendent of Documents, Washington, D. C.

Stoker—Catalog 7060 containing 16 pp. is a complete treatise on the Iron Fireman Pneumatic Spreader Stoker. Topics treated are: mechanical feeding and metering of coal; pneumatic conveying of coal to furnace; combustion of coal in furnace; automatic control of combustion and operation and variable speed drive. The Iron Fireman Mfg. Co.

Valves and Piping

Corrosion-Resistant Valves and Fittings is the title of a new 56-pp. booklet containing 8 pp. of colored charts for convenient reference. Nearly 200 chemical solutions used in process manufacturing are listed alphabetically. In addition to the chemical and physical properties of various alloys, their general behavior in process piping, the kinds of industries for which they are recommended, detailed information on a large variety of valves, fittings and fabricated piping for corrosion-resisting services. Crane Co.

Valves—Crosby safety and relief valves are illustrated and described in a new 112-pp. Catalog No. 103. Various types of valves, sizes, pressure and temperature ranges and the services for which they are designed are described in detail. Crosby Steam Gage & Valve Co.

Ni-Resist Pipe—A new bulletin describes corrosion and heat resistant cast iron pipe. A tabular comparison of corrosion resistance for Walworth Ni-Resist against unalloyed cast iron gives the corrosion rate in milligrams loss per square decimeter per day when the pipe is subjected to various corrosives at different concentrations. This corrosion chart is accompanied by an interesting photographic comparison showing the corrosive effect on two samples after 1 wk. submersion in five per cent sulphuric acid at room temperature. Walworth Co.

Welding

Welding—A new 20-pp. booklet covering a complete line of welding accessories and electrodes has just been issued by The Hobart Brothers Co.

Welder—Bulletin No. 308 describes the 200-amp. Shield-Arc junior welder. The Lincoln Electric Co.

Metal—Tentative specifiations for iron and steel arc-welding electrodes approved by both the A.W.S. and the A.S.T.M., along with other useful material, are included in a 24-pp. catalog E-16 just issued by The McKay Co.

Electrical Equipment

Switch and Bus Insulators—This catalog gives complete data on all standard N.E.M.A. and several specially designed switch and bus insulators. A line of conductor clamps, adapters and spacers is also shown. Porcelain Products, Inc.

Electrical Equipment — Leaflet B6023 describes the type D-20 and KD-20 moderate capacity switchboard type oil circuit breakers. Bulletin B6043 on the Chlorextol filled transformers outlines savings which can be obtained by this type of transformer. Allis-Chalmers Mfg. Co.

Replacement Motor Starting Capacitors is the title of a new catalog No. 162 listing exact duplicate replacement capacitors for all types of a.c. motor driven equipment from air conditioning down to water systems. Included in the catalog listing are the type and catalog number of each unit, together with the capacity, a.c. voltage rating, dimensions and list price. Cornell-Dubilier Electric Corp.

Electrical Equipment—Fourteen new bulletins have been issued discussing various types of electrical equipment. The numbers and subjects of the bulletins are: GES-2372 Relaying News; GEA-3248, new D-C magnetic starter, CR4052; GEA-3280, Cable Digest; GEA-1758B, Rectangular Switchboard Instruments; GEA-1784B, Portable Instruments; GEA-246F, High-speed synchronous motors; GEA-1811B, Plunger-Type Relays; GEA-2022C, Diactor Generator-Voltage Regulators; GEA-3339, Time Switches Type T-27; GEA-1993F, Enclosed Indicating and Dropout Fuse Cutouts; GEA-3250, New Smaller Magnetic Starter; GEA-3255, Fuses for Network Protectors; GEA-2707A, Reclosing Fuse Cutouts; GEA-2494A, Pyranol Distribution Capacitors. General Electric Co.

Condensers

Barometric Condenser—A new 20 pp. bulletin, No. 9424, covers the disc-flow, counter-current type barometric condensers: advantages; operating diagrams; complete specifications; suggested arrangements; and auxiliary equipment. Ingersoll-Rand Co.

Condensate Return Units—Bulletin 260-B14C, along with a combination selection table and price list, Form L14E, covers a complete line of automatic condensate return units for vented gravity systems. Roots-Connersville Blower Corp.

Water Treatment

Water Treatment — The second printing of the 20 pp. booklet entitled H-O-H Lighthouse Reprints contains practical information regarding various water problems. Causes of scale and corrosion are explained in every day language and methods of correction are described along with information regarding the quantities of corrective agents needed under varying conditions and the relative importance of plant control tests and laboratory analyses are also clearly outlined. D. W. Haering & Co., Inc.

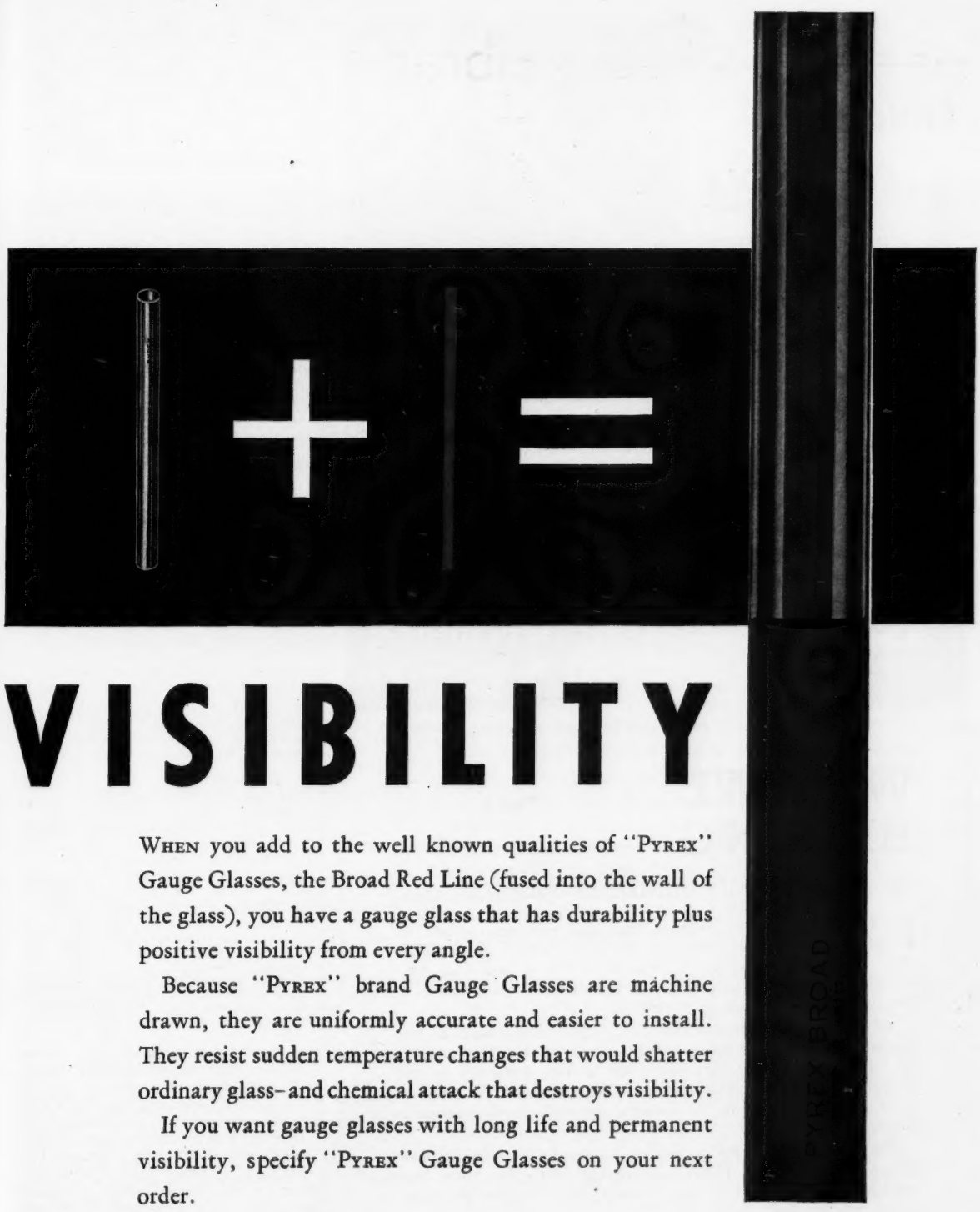
Water Treatment—Infilco products for chemical mixing, feeding and proportioning, for hydraulic measurement and control, and for conditioning water, processing liquids and trade wastes, all are illustrated and briefly described in a new condensed catalog No. 50. International Filter Co.

Heat Exchangers

Alco Pressure vessels and heat exchangers are illustrated and described in a new 4-pp. bulletin issued by the Alco Products Div. of American Locomotive Co.

Cooling Towers. — Induced draft cooling towers for industry and air conditioning are described and illustrated by typical installation and construction photographs in a new 32-pp. bulletin in color. The Marley Co.

Air Preheater—A new catalog illustrates and describes the Ljungstrom air preheater. Two general types of preheaters are illustrated and described, which differ only in details of construction to accommodate horizontal or vertical flow of the flue gas and combustion air. The Air Preheater Corp.



VISIBILITY

WHEN you add to the well known qualities of "PYREX" Gauge Glasses, the Broad Red Line (fused into the wall of the glass), you have a gauge glass that has durability plus positive visibility from every angle.

Because "PYREX" brand Gauge Glasses are machine drawn, they are uniformly accurate and easier to install. They resist sudden temperature changes that would shatter ordinary glass–and chemical attack that destroys visibility.

If you want gauge glasses with long life and permanent visibility, specify "PYREX" Gauge Glasses on your next order.

PYREX

Pyrex GAUGE GLASSES

BRAND CORNING GLASS WORKS, CORNING, N.Y.

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works.

Endorse

SAFE TOOLS in your plant

Are you aware of the dangers that lurk in the average tool box . . . throughout your plant special control devices operate to promote safe working conditions for man and machine, but hidden in many a tool box are wrenches and hand tools that are relics of a bygone day—open end wrenches with worn and spread jaws, cracked box wrenches, old monkey wrenches that slip and chew up bolt heads—tools that spell DANGER. Put an end to this condition with Snap-on wrench equipment . . . endorse the use of safe tools for production set-up and plant maintenance. There's a Snap-on for every job from tiny meter work to the biggest, toughest nut-turning job in your plant.

Complete information about Snap-on's tool service gladly sent on request . . . available only through our 35 factory branch warehouses. Write . . .

SNAP-ON TOOLS CORPORATION
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ABP

Miscellaneous

Spraying Equipment—Catalog No. 75 illustrates and describes a complete line of industrial spray finishing systems, including spray guns, spray booths, air compressors, painting outfits, extractors, respirators and hose. Binks Mfg. Co.

Exhausters and Boosters—A 20-page bulletin No. 32-33-B-11, illustrates and describes the rotary positive gas exhausters and boosters. Pressure-volume curves and information regarding operating characteristics of this equipment are given and various arrangements for motor, gas engine and steam engine drive are illustrated. The Roots-Connersville Blower Corp.

Cutting Speed Conversion Tables showing the revolutions per minute required for turning bar stock at surface speeds of 90 to 550 ft. per min. with Kennametal steel-cutting carbide tools, have just been made available by McKenna Metals Co.

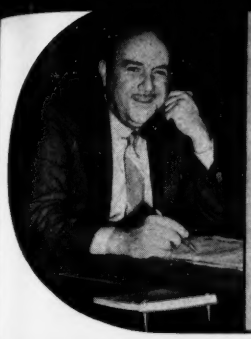
Potentiometer Recording Pyrometers—A 15-pp. illustrated booklet, 190-3, provides complete data on these instruments for use in recording of industrial temperatures. A table of potentiometer chart ranges as well as complete specifications of Foxboro recording potentiometer pyrometers are also included. The Foxboro Co.

Dust Collector—Bulletin No. 197 gives a description of the type CH all metal cloth screen dust collector for industrial service. It illustrates and describes the many exclusive features not previously available in this class of equipment. Pangborn Corp.

Insulation—This Thermal Insulation Manual, presented in data sheet form, has been prepared to assist the many men in business who are interested in choosing, applying or using thermal insulations. This manual is divided in sections and covers the following subjects: technical information on insulations, heat insulations, cold insulations, insulation accessories and fireproofing materials, Durant pre-sealed insulated pipe, insulation recommendations and specifications, refractory cements, packings, building insulations and materials, asbestos fibres and textiles. Ehret Magnesia Mfg. Co.

Safety Appliances—A 32-pp. catalog, designated as supplementary Catalog No. 600, shows advanced and specially designed safety appliances. Among them are relief valves designed for extremely high pressures and temperatures, an improved model of a steel pop safety valve and a high pressure relief valve with either a monel or stainless steel seat. A phenol case refinery gage is one of the further new products fully described. This catalog contains helpful engineering information such as discharge capacities, maximum temperature and pressure ratings as well as capacity and temperature conversion factors. J. E. Lonergan Co.

Thermix Topix is the name given a new house organ that is to be published quarterly by the Prat-Daniel Corp.



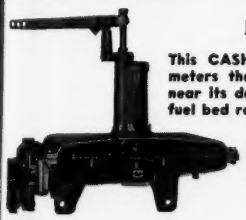
"DID YOU SAY IT ONLY COST YOU $98.00 TO GET AN IMMEDIATE START ON THE COST-SAVING BENEFITS OF AUTOMATIC COMBUSTION CONTROL"

"YES SIR, ALL I HAD TO DO WAS INSTALL THE CASH STANDARD FURNACE DRAFT CONTROLLER··· YOU SEE IT WORKS INDEPENDENTLY AND IS DOING A SWELL JOB, AND, WHEN I WANT TO COMPLETE THE SYSTEM ALL I NEED DO IS TO ADD THE OTHER UNITS"

YOU CAN GET THIS FURNACE DRAFT CONTROLLER FOR ONLY $98.00

This CASH STANDARD Furnace Draft Controller (which comes complete with Operating Power Cylinder) works from over-fire draft, regulating the boiler uptake damper, to maintain a constant draft in the combustion chamber. Place it near the up-take damper. It works independently of either of the two Controllers shown below. It does its part toward money saving by eliminating wasteful air infiltration.

ADD THE REST OF THE SYSTEM LATER . . . TO MAKE IT COMPLETE FOR ONE BOILER

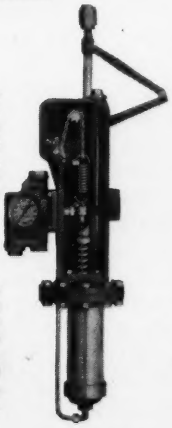


AIR FLOW CONTROLLER

This CASH STANDARD AIR FLOW CONTROLLER meters the air needed for combustion. Install it near its damper. It is not affected by changes in fuel bed resistance or any other variables, because it meters air supply according to the differential pressure through the gas passages of the boiler, doing its part to insure perfect combustion.

FUEL FEED CONTROLLER

This CASH STANDARD Master Controller automatically regulates fuel feed. Locate it conveniently. Working from boiler pressure, it will adjust the rate of combustion by regulating the rate at which fuel (any kind of fuel) is supplied to the boiler furnace. And it will adjust the Air Flow Controller so the correct amount of air is supplied for proper combustion—hence, money saving.



OIL CIRCULATOR

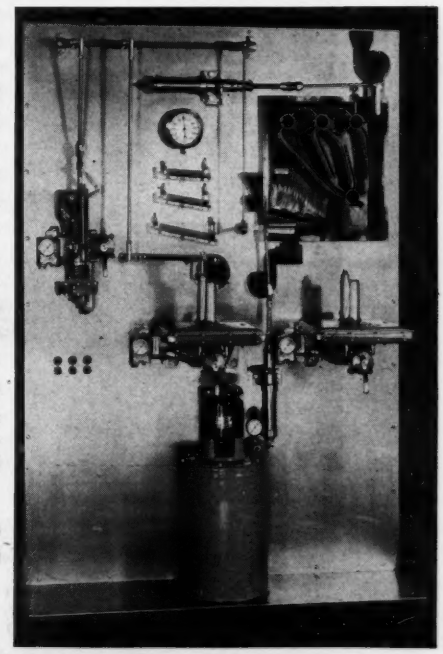
The purchase of this oil circulator is optional. All three Controllers shown above can be properly operated by clean water, but it is preferable and cheapest in the long run to operate this equipment with this CASH STANDARD Oil Circulator, price $108 equipped with 110-220 v. 60 cy. motor.

That sir, can be your answer to an easy and convenient way to get started on the cost-saving benefits of Automatic Combustion Control—it's a first step through a simple purchasing plan based on a $98. initial outlay. And, adding the rest of the system is not expensive.

In CASH STANDARD you get the very finest equipment made. The control units that we furnish for installations made on this plan are the same CASH STANDARD units we sell for the most elaborate kind of job and for the largest kind of boilers.

The one requirement necessary to make this money-saving plan workable is that you install the control units conveniently near the apparatus they operate, without panel board.

You get Fuel Feed Controller, Air Flow Controller, with Operating Power Cylinders included (as in the Furnace Draft Regulator), and necessary connecting fittings — all for as little as $290. If you want CASH STANDARD Control System on panel boards, you can get them but we emphasize that the control units work just as well mounted individually elsewhere. Here you see a portable display panel on which full size control units (with miniature boiler) work automatically to show the real sensitivity, accuracy, and dependability of the CASH STANDARD System.



Get the complete facts — write for bulletin 963-A-B.

A. W. CASH COMPANY
DECATUR, ILLINOIS

CASH STANDARD
CONTROLS . . VALVES

When they yell
"Give it the gun . . . we got orders"
Keep power flowing
. . with the

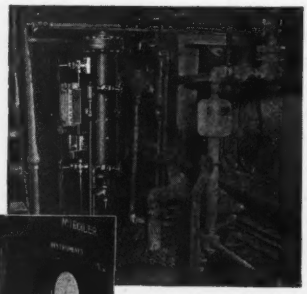
YOU can't afford to let the cost of boiler water level safety endanger your production when you've "got orders," especially since safety devices cost nothing compared to expensive plant shut-downs and accidents. Keep power flowing with the double protection of Reliance ALARM and EYE-HYE . . . the water level safety team.

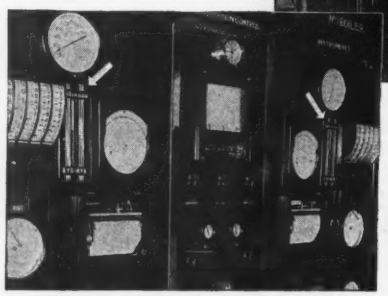
The ALARM—your SOUND check—warns by whistle or electric signal when water levels reach dangerous stages, calls operators anywhere in the power plant. It's sensitive to slightest water level changes; action is quick and positive, controlled by non-sinkable patented floats. Continuously improved through 56 years manufacture.

It's even more efficient to *prevent the need* for water level warnings. SIGHT check with EYE-HYE, the remote reading gage that brings your water level to the instrument panel or any convenient point—right before your eyes. Here's minute-to-minute reading, accurate, sharp and clear in brilliant green, illuminated. Hooks up quickly, easily—two flexible tubes to the drum.

There's no time now for power repairs. Make yourself a new efficiency record in today's profit opportunity—*keep* power flowing. Write today for bulletins on ALARM and EYE-HYE.

The Reliance Gauge Column Co.
5902 Carnegie Ave • Cleveland, Ohio





SOUND *The ALARM at RCA Mfg. Co. plant, Camden, N. J., on 900 pounds pressure service.*

SIGHT 2 *EYE-HYEs on the panel at RCA, save thousands of steps, add extra safety. . . . .*

Reliance
TRADE MARK REG. IN U.S. PAT. OFF.
Boiler Safety Devices since 1884

Combustion Space for Underfeed Stokers

CORRECT combustion space and setting height that should be allowed in boilers fired by underfeed stokers using bituminous coal have been made the subject of a field survey recently completed. The research work in the field was conducted by engineers of Battelle Memorial Institute for the Stoker Manufacturers Association, the National Coal Association, the Institute of Boiler and Radiator Manufacturers, and the Steel Heating Boiler Institute with the Smoke Prevention Association cooperating.

The report, which was first presented as a paper in abstract form by R. C. Cross, R. A. Sherman, and H. N. Ostborg, engineers of Battelle, at the recent annual meeting of the Smoke Prevention Association in Milwaukee, was recently approved by the Steering Committee at a meeting held in Chicago. The report is now ready for release. It is in mineograph form and in its 33 pages of text and in 19 figures it presents the data obtained in a factual survey of 102 installations and an experimental study of 22 installations in Columbus and Cincinnati, Ohio; St. Louis, Mo.; and Chicago, Ill. The survey included both high and low volatile coals and cast-iron and steel boilers fired with stokers burning 20 to 900 lb. of coal per hour.

On the installations of the experimental survey, the smoke emission was recorded continuously by a photo-electric type of instrument. In addition, the temperature and composition of the flue gases, the rate of coal feed, the drafts and pressures, and attention to the stoker were recorded. The coal used was sampled and analyzed.

Brief discussions are included on the fundamentals of smokeless combustion and it is pointed out that the underfeed stoker operates on the correct principle, that of liberation of the volatile matter at a level where ample air is supplied for its combustion. The principle does not hold when the distribution of air and coal is non-uniform and when the stoker shuts off. In 19 of the 22 installations the smoke emission was greater in the "off" periods than in the "on" periods of the stoker.

Furnaces, it is stated, are not meant to be smoke consumers; the way to prevent smoke emission from chimneys is to prevent its formation at the fuel bed rather than to let it form and then to attempt to burn it in a large combustion space and by a high excess of air. To do so in the average stoker installation means high maintenance cost and lower operating efficiency. Furthermore, the type of coal, the excess air carried the uniformity of distribution of the coal on the stoker, the type of load, and the degree of intelligence and ability of the operator are of equal importance in elimination of smoke as the rate of heat liberation or setting height.

(Continued on page 122.)

R P&C CO

FIG. 9001 CAST STEEL GATE VALVE

AGAIN...

cooperation that cuts the cost of steam

Many problems were presented by a recently completed public utility steam power plant in which responsibility for valve performance was placed largely in our lap—main steam manifold valves shown below.

We naturally are happy that READING-PRATT & CADY cooperation had its share in the new low costs achieved and assure you equally practical suggestions when you write us about *your* valves.

READING-PRATT & CADY

READING-PRATT & CADY DIVISION · BRIDGEPORT · CONNECTICUT

AMERICAN CHAIN & CABLE COMPANY, Inc.

WRENCH ABUSE

Darts

ARE BUILT TO TAKE IT

You don't have to chin yourself on a wrench to get a tight joint with Dart unions. Because Dart seats are ground and matched for true ball, wide bearing, leakproof joints *without jamming*. But all the same Darts can take wrench abuse and come out on top every time. Bodies and nuts are extra heavy, made from air-refined malleable iron, tested for uniformity and toughness. . . . Standardize on Darts. Write for one to try.

DART
UNIONS

E. M. DART MFG. CO., PROVIDENCE, R. I.
Sales Agents: The Fairbanks Company, New York, and all branches
Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

At its meeting in Chicago recently the Steering Committee requested the Engineering Committee of the Stoker Manufacturers Association to prepare and submit recommendations on minimum setting heights for underfeed stoker-fired boilers to be submitted to the various industries undertaking this study for adoption as tentative standards of the Steering Committee in order that uniform practice may prevail.

Copies of the official report entitled A Field Survey of the Relation of Combustion Space and Setting Height to Smoke When Firing Bituminous Coal with Underfeed Stokers are available at a nominal price from the Stoker Manufacturers Asso ciation, 307 North Michigan Ave., Chicago, Ill.

Air Conditioning Aids Draftsmen

EXECUTIVES of the Detroit Edison Company have reported to the Air Conditioning Manufacturers Association that, since moving into their new air conditioned, windowless office and service building, an improvement of 51 per cent in the summer output of drafting room employes has been accomplished.

Because of the radical departures from conventional design, the new building has attracted wide attention from engineers and architects. It is entirely without windows, six stories high, and covers an area 248 by 120 ft. Daylight enters each floor through a band of glass bricks around the building at each floor level. Supplementary light is provided by a special electric lighting system which insures an illumination of 50 foot-candles at the desk top.

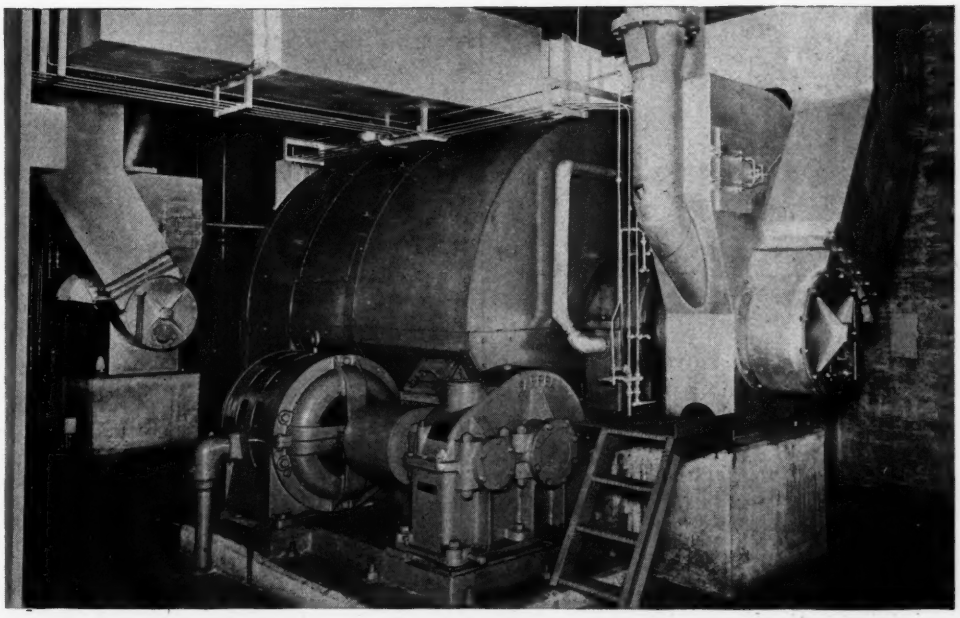
Complete air conditioning and high intensity lighting permitted the design of a purely rectanglar building, without the "courts" which are traditionally employed to bring a measure of daylight and natural ventilation to working areas. The six-story building contains as much usable space as a conventional eight-story structure without air conditioning, so that the cost of the air conditioning was more than offset by the savings it made possible in construction and maintenance.

Curious to find out what effect the "perfect environment" was having on the office force, executives of the company selected the drafting and surveying bureau as a gage of efficiency, because that department had adequate time-study records before and after moving into the new building. The amount of time needed for a draftsman to make an average map, or an average number of map changes, had been used to establish an average "work unit" as a yardstick of a draftsman's progress.

During the summer before the offices were air conditioned, 8988 work units required 5008 man-hours. During the summer after the new air conditioned building was occupied, 10474 work units required only 3872 man-hours—an increase in efficiency of 51.4 per cent.

(Continued on page 124.)

Repeat Orders



for ball pulverizers

The final proof of excellence of power plant equipment is the satis-- faction of users as expressed in repeat orders.

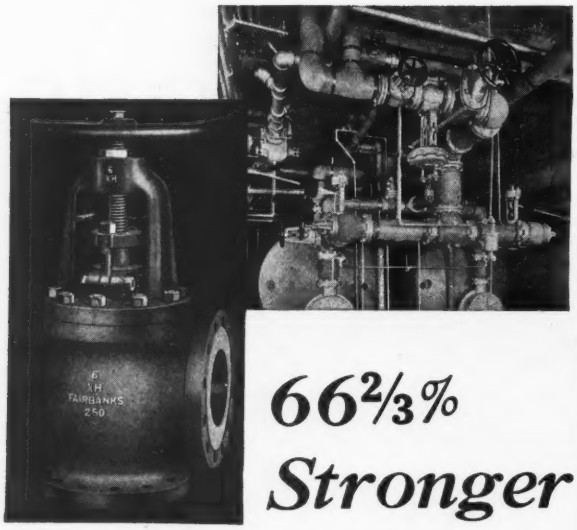
The 1939 repeat orders for Foster Wheeler conical ball pulverizers include:—

First repeat order for 2—30,000 lb. per hour mills.....Total, 4
Third repeat order for 2—25,000 lb. per hour mills.....Total, 10
Second repeat order for 4—33,000 lb. per hour mills.....Total, 12*
Second repeat order for 1—12,000 lb. per hour mill.....Total, 3**
Fourth repeat order for 2—15,200 lb. per hour mills.....Total, 9

(*) In 2 years.
(**) For anthracite fines.

FOSTER WHEELER CORPORATION, 165 BROADWAY, NEW YORK, N. Y.

FOSTER WHEELER



66⅔% Stronger

Fairbanks Iron Valves are made of a special high-test alloy iron which has a tensile strength of 40,000 lbs. per sq. in. This is about 66 2/3% greater than ordinary cast iron, giving greater strength to withstand pipe strains and sudden shocks.

The rolled naval bronze stem, with full cut Acme threads, makes the valves operate more easily. You will never have trouble opening or closing them.

When you need valves on which you can take no chances, especially for installations like the above De Paul Hospital, St. Louis, Mo.—where valve failure might curtail the water supply or fire-prevention systems and jeopardize the lives of hundreds of patients—install the dependable Fairbanks Valves.

Fairbanks Valves are made in bronze and iron for a large range of pressures, with screwed and flanged ends, in globe, gate, angle, check and cross patterns.

Write for catalog No. 21 and name of the nearest Fairbanks distributor.

THE FAIRBANKS COMPANY

Valves, Dart Unions, Hand Trucks and Wheelbarrows

399 Lafayette St., New York, N. Y.

Boston, Pittsburgh—Distributors in Principal Cities
Factories: Binghamton, N. Y., Rome, Ga.

Fairbanks Iron Valves

When this figure appeared to be phenomenal, executives checked up on it by discussing the question with several drafting room employees. One man reported that his actual loss of time during hot, sticky weather was influenced by a great many factors over which he had no control. Starting on a piece of work, he would discover that his elbow had made a smudge on the paper. It had to be erased. Tracing paper would be blown to the floor by the draft from an open window. Paper on the board would get dirty from the same source.

The result of these many small inconveniences and distractions was that the amount of actual time required to finish a given piece of work was greatly increased in a room without air conditioning.

Another draftsman commented on the effect of air conditioning on the tracing of maps. Because tracing cloth is made of a specially-treated cotton fabric, the fibers stretch appreciably under humid conditions. When sections of a large tracing were made on two or three successive days, they would not fit if placed side by side, although they had been made from adjoining parts of the same map. The maintenance of an even humidity, through air conditioning, solved this annoying problem to perfection.

Finally, the complete comfort of workers in the air conditioned drafting room was regarded as a leading factor contributing to greater efficiency of the department.

Boiler Failures

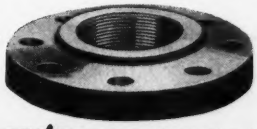
ACCIDENTS due to defects in boiler construction or operation are constantly decreasing and it is surprising that in the whole state of Wisconsin covering a period of two years there were not more than 14 involving steam boilers and their appurtenances as reported recently to the National Safety Council. Due to these 14 accidents, however, three persons were killed and fifteen were injured which emphasizes the need for extreme care in operation. It was also reported that during this same period, out of a total of 38,797 boilers inspected, 3701 were examined by the Industrial Commission Boiler Inspectors. Of 3622 boiler defects, there were these percentages noted:

Pitting or corrosion	11%
Oil or scale	12%
Leakage	8%
Defective tubes	6%
Fusible plug, defective or misplaced	1%
Water glass, low or defective	2%
Safety valve, defective or improperly installed	8%
Steam gage, missing or defective	3%
Defective water column or connections	9%
Gage cocks, missing or defective	5%
Excessive pressure carried	2%
Other defects	33%

Twenty boilers were condemned, about ½ of 1% of those examined by State Inspectors.

DROP FORGED FOR SAFETY AND ECONOMY UNDER THE MOST TRYING CONDITIONS

Valves, Fittings and Flanges by Vogt — the choice of operating men everywhere for safe and sure regulation of the high pressure and high temperature liquids and gases used in modern process work.



Vogt PRODUCTS are

HIGH OPERATING EFFICIENCIES AND LOW MAINTENANCE COSTS

More steam per dollar of investment—because Vogt Boilers are designed and built to fit in with specific operating conditions. Available in bent tube, sectional header, box header and return tubular types using coal, oil, gas or waste heat for fuel.

DESIGNED to RAISE

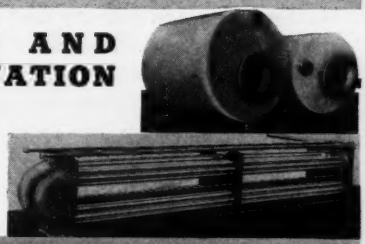
MEETING THE DEMANDS FOR OPERATING SECURITY

Vogt has every facility for the fabrication of stills, towers, continuous rotary filters, filter presses, oil chilling machines, heat exchangers, etc., and these products are serving the petroleum industry around the world.

OPERATING STANDARDS and

TO COMBAT CORROSION AND PREVENT PRODUCT CONTAMINATION

Process equipment made from special metals and alloys for the exacting service of the chemical plant is fabricated in our modern shops for many of the well known chemical companies.



LOWER YOUR COSTS

STEPS TONNAGE UP AND COSTS DOWN

Our experience of more than half century in building profit-making ice and refrigerating machinery is at your command. We make complete units for ice and cold storage plants, packing plants, dairies, breweries, chemical plants, oil refineries and related industries.

Vogt PRODUCTS

NEW YORK
PHILADELPHIA
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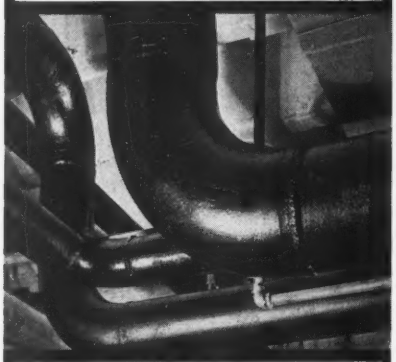
ST. LOUIS
CHICAGO
DALLAS

HENRY VOGT MACHINE CO., INCORPORATED LOUISVILLE, KENTUCKY

Insist on these
EIGHT FEATURES



—the welder knows their value

THE eight features of WeldELLS, illustrated here, do their own talking to the man who does the welding. There is no hunting for fittings, or "sizing up", because the name, size and weight are rolled into every Taylor Forge Fitting. Lining up is made easy by the quarter-markings at the ends. Welding is a quick, gratifying job thanks to the ample tangents, the clean, machine-tool bevels and the uniform accuracy of these engineered fittings.

The finished job is better too—because it is made with fittings in which all walls are at least full pipe thickness with selective reinforcement in regions where greatest strain occurs.

Ask for latest bulletin.

TAYLOR FORGE & PIPE WORKS
General Offices and Works: P. O. Box 485, Chicago
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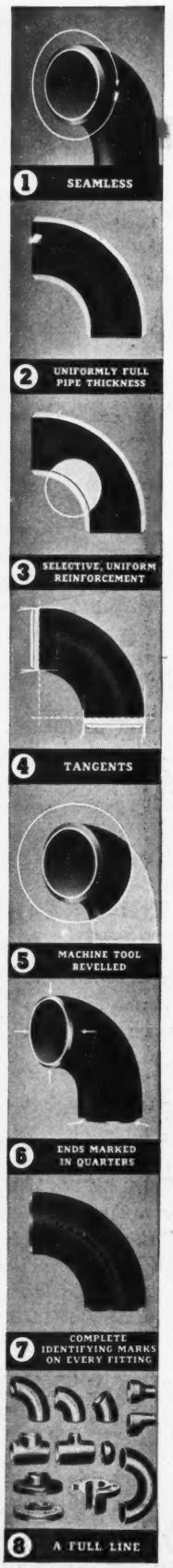
TAYLOR FORGE
WeldELLS
Seamless Pipe Fittings for Welding


1 SEAMLESS
2 UNIFORMLY FULL PIPE THICKNESS
3 SELECTIVE, UNIFORM REINFORCEMENT
4 TANGENTS
5 MACHINE TOOL BEVELLED
6 ENDS MARKED IN QUARTERS
7 COMPLETE IDENTIFYING MARKS ON EVERY FITTING
8 A FULL LINE

Power Resources and National Strength

POWER per man looms as a new gage of a nation's strength and may explain Germany's quick crushing of Poland, in the opinion expressed recently by Francis J. Pettijohn, assistant professor of Geology at the University of Chicago.

By this gage, Dr. Pettijohn pointed out, each German "outnumbered" each Pole in coal energy three to one; in iron, six to one, while petroleum production, negligible for both countries, was a standoff.

Dr. Pettijohn has been making a study of war and peace economics, with a geologic background, on the theory that "energy production of a nation is a true measure of its power potential.

"Coal, on this basis, figures most prominently in the world as an energy factor, with petroleum and water rounding out this category," said Dr. Pettijohn. "The minerals, from which tools to transmit the energy in war or peace economies come, are the second criterion, with iron the most important single mineral.

"While the Reich's population is approximately three times that of Poland, the true discrepancy does not appear until the power per man is contemplated."

Dr. Pettijohn cited a breakdown of nations of the world on the basis of their fuel, iron, precious metals and ferrous alloys, made by Professor Edward Sampson, of Princeton University. In this breakdown, Germany "outnumbered" Poland more than seven to one.

"This analysis," said Dr. Pettijohn, "also may reveal why Italy has remained so quiet, and throws into sharpest perspective, from a world standpoint, the dominant position of the United States.

"Italy has no oil, virtually no iron ore and copper, and no coal."

The United States and Alaska, in this weighted power breakdown, have more than a third of the entire world's exploited power—34.1 per cent.

Others are:

British Empires	21.3
(United Kingdom	4.9)
French Empires	8.5
(France	6.7)
Germany	7.3
Russia	3.7
Poland	1.0
Japan, including Korea, Manchukuo	1.3
Italy	1.3
China	1.2

"Poland's conquest appears to be the first 'lesson' on the power of exploited natural resources," said Dr. Pettijohn. "I think that these geologic criteria may, on further investigation, provide sound basis for projecting peace as well as war strengths."

LOWER **Fuel Expense**

Reduce **Boiler Maintenance**

with **Swartwout**

Deaerating Feed Water Heaters

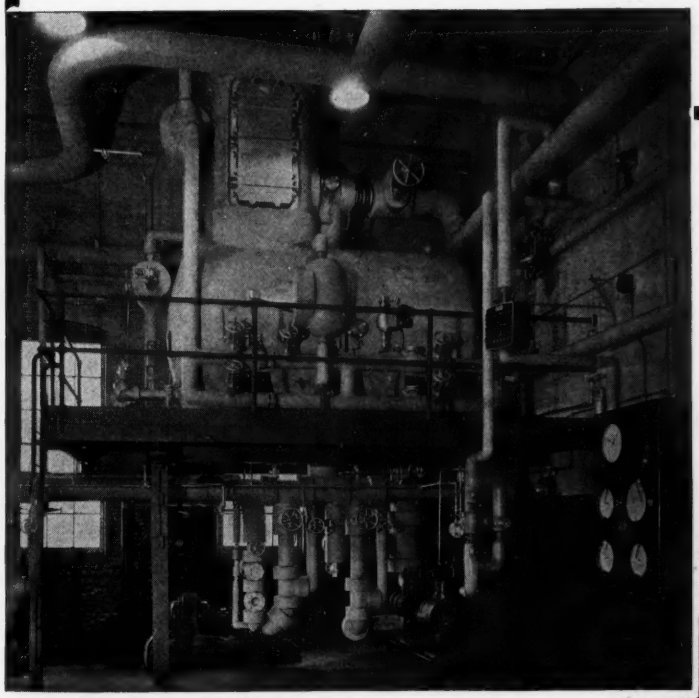
Preheat and deaerate your boiler feed water and you get greater fuel economy and less trouble from lime and scale — a costly maintenance problem.

Swartwout Heaters, tailored to your needs, *guarantee oxygen removal* and preheating capacity, backed by Swartwout's more than 30 years experience.

Rugged construction — leak-proof joints — no rumbling, noise or damming of water — easy accessibility of trays — ample storage capacity. Swartwout engineers consult with you on all requirements.

In your new power plant or when you modernize an old one, make sure of trouble-free heater operation and pride-satisfying efficiency.

Write today for new bulletin S-18-D —address The Swartwout Company, 18541 Euclid Ave., Cleveland, O.



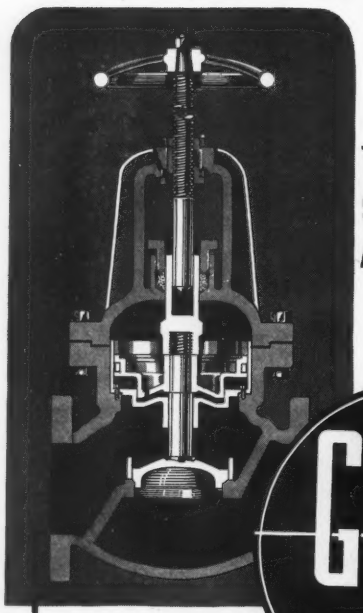
Left—A Swartwout Feed Water Heater installed and in operation in a large eastern power plant.

Below—The same heater in the Swartwout plant—tested and ready for shipment.

Feed Water Regulators • Pump Governors • Feed Water Heaters
Master Controls • Reducing Valves • Separators • Exhaust Heads

Swartwout

·Power Plant Equipment·



THEY SHUT DOWN STEAM FLOW AUTOMATICALLY

G-A Valves

FOR SAFETY

Emergency . . . . Boiler Failure or Steam Line Burst . . . . will a man make a dash to shut off the valve and risk his life? No . . . . not with a G-A Automatic Shut-off Valve on the job.

These valves are the only dependable safety stop valve for all emergencies . . . . proven by over 30 years performance and thousands of installations . . . . accidents are prevented . . . . property and life are saved . . . . bring your safety up-to-date . . . . equip now with G-A Valves.

G-A Valves are "tailored" to meet every possible requirement. Always designed to suit the particular operating needs and safety requirements. Write for complete descriptive literature or submit your valve problems for analysis by our engineers.

GOLDEN-ANDERSON
Valve Specialty Co.
FULTON BUILDING - PITTSBURGH, PA.

Conveyor to Handle Aggregate

COLUMBIA Construction Co., Inc., of Redding, California, has contracted with the Chain Belt Co. to furnish the belt conveyor idlers for the longest belt conveyor system ever installed. This 9.6 mile belt conveyor will furnish the aggregate for the construction of Shasta Dam, which is being built by the U. S. Department of Reclamation for irrigation purposes in the Central Valley of California.

Over 16,000 troughing and return belt idlers will be used in making up this transportation system. Twenty miles of 6-ply belting 36 in. wide, will be required for the system and will be supplied by Goodyear Tire & Rubber Co.

This conveyor system which is between Redding and Coram, California, will be erected on wooden bents varying in height above the ground from 4 to 90 ft. and will be composed of 26 individual belt conveyors. These 26 links of the system will each be motivated with a 200-hp. motor except for three down grade units which will generate their own power. The weight of material on the slope makes these belts self-operating.

The course of the conveyor will be through the middle of an 80-ft. right-of-way, cleared through manzanita brush its entire length. It will cross the Sacramento River at two points; over one main state highway and five county roads; across four creeks and the main line of the Southern Pacific Railroad.

In several places the conveyor will deviate from the straight line of haul to avoid hill tops on a direct line between the gravel plant at Redding and the delivery site at Coram.

The capacity of this transportation system will be 1100 tons per hour. While conveying at a speed of 550 ft. per min., the material in transit will be on the conveyor 1 hr. and 40 min.

Four years of operation will be required to meet the total demands of the dam construction project which is estimated at 10,000,000 tons of aggregate.

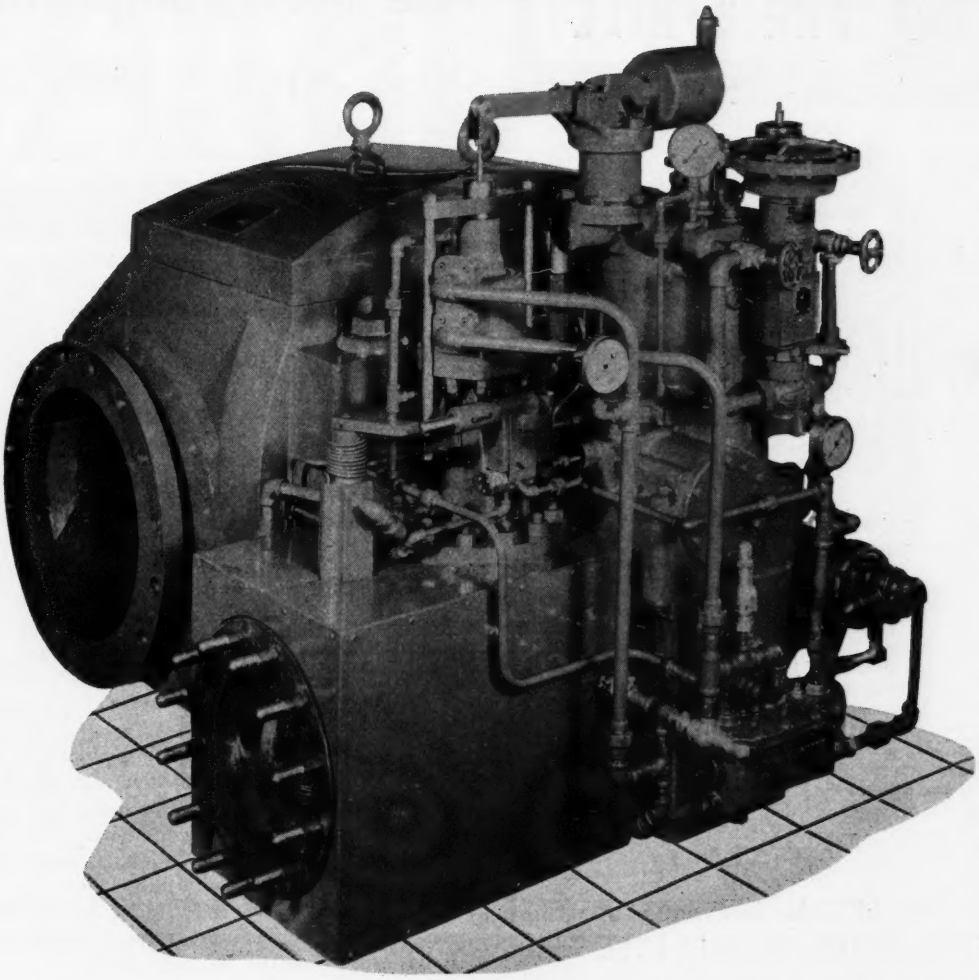
Greatest daily requirement of aggregate at the dam site will be 22,000 tons and the conveyor working at capacity can deliver 26,400 tons in a 24 hr. day. This system will operate on a 24 hr. daily basis and build up reserve supplies of aggregate at the dam, rather than attempt to match daily requirements.

When completed, the system will be illuminated its entire length with sodium vapor lights, providing a spectacular sight to air travelers or others situated at high altitudes over a wide area. The purpose of the lighting is to make continuous operation during the night possible. There will be telephone stations at numerous points along the system and a motorized patrol will constantly be on duty. The system will have interlocking self-control arrangements which will stop the entire conveyor if anything should interfere with operation of any one unit. This interference will be indicated on a central control panel.

During the rainy season, a temporary cover will be built over the entire system to protect the sand from getting wet in transit.

MURRAY STEAM TURBINES

For Driving Centrifugal Compressors and Blowers



Builders of Steam Turbines, Boilers and Engines

MURRAY turbines are available for driving centrifugal compressors and blowers over a wide range of operating conditions. The above photograph is a typical example. Two of these MURRAY turbines, together with a third similar MURRAY unit, drive centrifugal air conditioning machines in a large Midwestern university.

This turbine develops 256 H.P. at 6460 R.P.M., using dry saturated steam at one pound per square inch throttle pressure, exhausting at 25" vacuum.

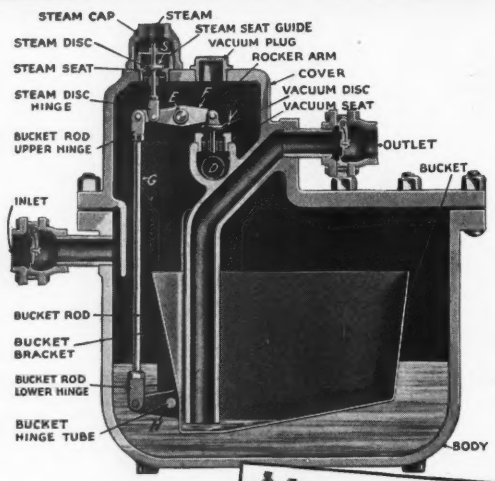
A variable speed oil relay governor with automatic controls varies the speed to give constant air conditioning temperature under all load conditions.

Let us recommend money-saving MURRAY steam equipment to suit your requirements. Address our district sales representative or Home Office.

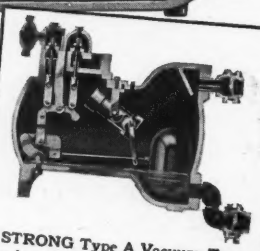
MURRAY IRON WORKS COMPANY, BURLINGTON, IOWA.

PIPEWRENCH PETE SAYS:

THIS TRAP MAKES LIQUIDS RUN UPHILL!



ABOVE: Strong Type M Trap removes liquids from a vacuum or low pressure and discharges to point higher than trap or against back pressure. Uses steam, air or gas only in equal volume to liquid removed.



STRONG Type A Vacuum Trap, primarily for atmospheric-gravity discharging. No steam required.

PLENTY OF SPECIAL FEATURES IN THESE POSITIVE-ACTING, TROUBLE-FREE TRAPS

It's no cinch to lick drainage problems like those you find in condensing engine exhaust lines, vacuum heaters, sump holes and the like. But STRONG has the right answer to all of 'em in these two traps for vacuum, lifting and pumping service—and built to handle water, oil or gasoline.

You'll find lots of smart engineering in 'em to help you do a better job and save the plant important money!

For complete details on this equipment, plus tips on making vacuum or lifting systems work better, get Catalog 64-PPE6 on STRONG Vacuum and Lifting Traps. No obligation, so drop a card now to . . .

The Strong, Carlisle & Hammond Co.
1392 West Third St., Cleveland, O.

STRONG
STEAM SPECIALTIES

Building Costs Are Not Comparable on a Square Foot Basis

IN A recent communication from Charles A. Haynes, of Albert Kahn, Inc., Architects and Engineers the statement is made that "We are continually being asked the square foot costs of industrial buildings—sometimes in terms of total area, but more often for a building of a specific size, for example 200 by 800 ft. It is our experience that this question cannot be satisfactorily answered without first making a survey of general conditions. Though we have accumulated cost data on practically every type of industrial building in various localities, we are unable to give any definite answer to the request without first investigating the general plant requirements. For our own convenience and information, we have on several occasions attempted to develop square foot cost curves, based on specific territories and similar types of building, but have discarded these as we found that due to the variations in codes, owners' requirements, etc. (even in the same type of industry), it is impossible to develop any information which could be intelligently applied by experts. Any such information would be extremely dangerous in the hands of the layman.

"While an industrial plant is primarily a covering for the protection of personnel and equipment, it should be so designed as to afford comfort and pleasant surroundings for the personnel. Yet to obtain the maximum production efficiency, comply with the national, state, city and trade codes, and varying policies of owners, the additional facilities in many cases rapidly increase the total building cost over the basic price of the building shell."

Location of site affects the price per square foot, according to Mr. Haynes, through the nature of the soil, the amount of excavation or grading, the type of foundation work required the shape of the site, the proximity of roadways and railway sidings, and distance from building and capacity of the various public utility services.

Construction materials, ventilation, floor finish, column spacing, building height, all of which have a decided influence on the cost of the plant, must be considered together with the type of product manufactured. Building may be of reinforced construction or steel and brick, with any one of many combinations of local or specialized building products adapted to meet the particular requirements.

Industrial operations and different localities have a bearing on the type of personnel employed and this influences floor area, plumbing, lockers, and general as well as employe service equipment.

(Continued on page 132.)

LARGE OR SMALL

- The inherent properties for prolonging valve life are built into every Powell Valve — regardless of size.
- To Powell, the satisfactory operation of the 1/8" needle valve for closely regulating the flow of liquids or gases is equally important as the trouble-free performance of a large size high-pressure, high-temperature steam valve.
- Large or small—every Powell Valve means lower maintenance costs and smoother operation.

Specify

Write for the Powell Catalogs. Free on request.

POWELL VALVES

THE WM. POWELL CO. CINCINNATI, OHIO

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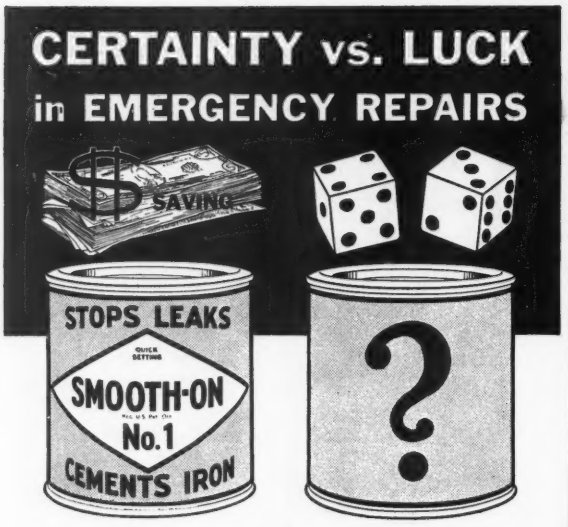
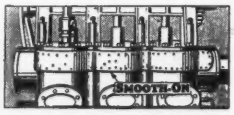


WHEN a pressure cylinder cracks, a boiler springs a sudden leak, or a head or main-line gasket blows, risk of prolonged shut-down is a costly price to pay for careless selection of the repair method and material. Such emergencies must be met quickly and in accordance with thoroughly dependable engineering practice.

Smooth-On repairs, made as instructed in the Smooth-On Handbook, are 100 per cent dependable, can be made in least time, with least effort, and at absurdly low cost. Usually no disassembling, renewal parts and reassembling are required.

Engineers can profitably keep a small supply of Smooth-On No. 1 and Smooth-On No. 3 always available, as Smooth-On repairs are safe, intensely practical and cheap, and in either emergency or routine work, will cut down maintenance expense.



Crack in pump cylinders sealed with Smooth-On

If you do not know all that can be accomplished with Smooth-On, and want a safe guide on good repair practice, mail the coupon for a free copy of the Smooth-On Handbook. This reference work is filled with helpful advice and diagrams for selecting the best repair method for the individual job, and for applying Smooth-On in the right way to get the best results.

Buy Smooth-On in 1 or 5-lb. can or larger package from your supply house or direct from us.

SMOOTH-ON MFG. CO., Dept. 31, 570 Communipaw Ave., Jersey City, N. J.
Please send SMOOTH-ON HANDBOOK

Name .....

Address .....

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1-40 .....

Do it with **SMOOTH-ON**

Mechanical service requirements not only vary with each industry, but in many of the departments within the individual plant. In connection with the heating, lighting and other power requirements, consideration must be given to whether services will be purchased from utility companies, or whether a power house is constructed in connection with the proposed plant.

While wage, material and insurance costs vary in practically every state, in some instances there are considerable differences even in adjoining towns. These unit differentials, building codes, variations in trade union jurisdiction or rulings, and the season of the year in which building is to be constructed again vary the unit costs.

These illustrations reveal the impossibility as well as the inadvisability of making snap judgments on the estimated cost of any type of building, and emphasize the need for an individual detailed preliminary review of actual requirements for each building before any appropriation is requested.

Texas Personnel Conference

THE FIRST Texas Personnel Conference held recently by the University of Texas was considered so successful that the 200 industrial and commercial personnel leaders of the state who attended voted to make it a permanent organization, and selected as head W. R. Woolrich, engineering dean, who served as chairman of the first parley.

Officials from seven fields of business—banking, department stores, insurance, manufacturing, newspaper publication, petroleum and utilities—as well as various governmental agencies attended the conference and took part in the discussion following the addresses and panels.

Addressing the conference, University President Homer P. Rainey suggested that America's back-to-school machinery, nearing complete breakdown, can be re-tuned only with a four-fold coordinating program touching schools, employers and employment agencies.

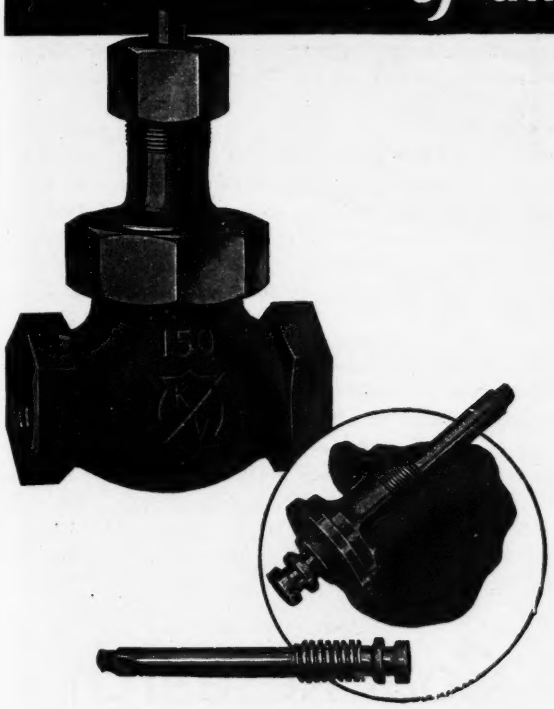
Urging cooperation between education and personnel officials in maintaining an unbroken record of each student's record of ability, he warned that "too often the school does a good job of keeping up with the student until he is graduated, and then the employer or employment agencies begin keeping track of him all over again.

"In the gap between, most of our job-misfits result," he said.

Following Dr. Rainey, John R. Suman, vice-president of the Humble Oil and Refining Company of Houston, spoke on the "Essentials of an Industrial Relations Policy."

(Continued on page 136.)

Inspect the MACHINE WORK *of any Kennedy Valve*



NOTICE the smooth, true surfaces, accurate threading, clean finish and perfect fit of all parts. Kennedy machinists are long-experienced, and the strictly modern automatic machine tools with which they are provided enable them to turn out flawless work.

The result—Kennedy Valves look trim and clean-cut; and, more important, they operate easily, close tightly, are readily taken apart and reassembled, and all parts are interchangeable.

The Kennedy 150-lb. Renewable-Composition-Disc Bronze Globe Valve which is illustrated has these additional important "extra values".

Union bonnet ring and packing nut made of malleable iron for extra strength; cadmium plated for permanent protection against rusting

Bronze-to-bronze true union joint between bonnet and body

Special machined low friction contact surface between stem head and disc holder for easy operation

Raised seat in body is unusually high for longer disc life

Slipon disc holder has four guide prongs to prevent binding—locks in wide-open position but releases at a half-turn of the stem

Stem has large number of heavy contact threads to reduce wear

Conical joint between stem and bonnet permits packing under pressure

Stuffing box is exceptionally deep with self-lubricating molded packing and long gland follower

Non-heating comfortable-grip handwheel

Every other Kennedy Valve type, too, has several "extra value" features that make Kennedys the best possible valve investment. Specify Kennedys on your next valve order and you will quickly see the advantages of standardizing on them. Obtainable at your local dealer.

KENNEDY

Products include

VALVES

Iron-Body and Bronze Gate, Globe, Angle and Check

PIPE FITTINGS

Malleable Iron and Bronze Screwed Fittings; Cast-Iron Flanged Fittings and Flanges

The Kennedy Valve Mfg. Co., Elmira, N. Y.

KENNEDY *VALVES with Extra Value*

YOU CAN PROFIT
BY A VISIT TO THIS EXPOSITION

Power engineers know from experience that their interests are promoted by attending this great exposition. You can profit in the same manner whether your work includes operating, servicing, buying, planning, designing or installing any part of a heating, ventilating or air conditioning system.

See the displays of more than three hundred exhibitors . . . have demonstrations made for you . . . talk to exhibitors . . . get ideas . . . bring yourself thoroughly up-to-date here in a single week. More than thirty thousand visitors are expected. They know from past years that it pays to attend. You too are cordially invited.

6th INTERNATIONAL HEATING & VENTILATING EXPOSITION

The Air Conditioning Exposition

LAKESIDE HALL, CLEVELAND, OHIO

JAN. 22-26, 1940

Auspices American Society of Heating & Ventilating Engineers
Management, International Exposition Co

108

The first session of the conference hinged on "Personnel Management Methods: A Clinic on Employe Selection," with Dean Woolrich keynoting the program by speaking on "Prologue to a Personnel Conference." Following a discussion of "Interviewing as a Selection Method in a Time of Labor Over-Supply," by Vernon McGee, assistant director of the Texas State Employment Service, two members of the same agency's staff staged a demonstration interview. John F. Hilliard, senior interviewer, represented the employee, and Roy L. Haynes, junior interviewer, took the role of the employee-applicant.

Dr. Chester F. Lay, university professor of management and accounting, discussed "Is the Current Growth of Personnel Technique Creating a Personnel Management Profession?" pointing out that personnel officers must demand a voice in creating the policies of the concern they represent, rather than acting as "stooges" for executives and boards of directors. He declared that personnel management must recognize the service obligation to employees before a professional standard can be achieved.

The second conference unit dealt with "Personnel and Industrial Relations Problems in Selected Business and Industrial Organizations."

The final session considered "Federal Legislation and Administration Affecting Employer-Employee Relations."

Coal Research

COALS and stokers are to be made the subject of a research project sponsored by the coal industry in the Missouri-Kansas District at the University of Kansas. A boiler and stoker have been installed and the University has awarded a Fellowship to an engineer to conduct experimental work on it during the 1939-40 school year. The coal operators purchased a 4500 sq. ft. steel heating boiler and stoker.

Weighing tanks for measuring the boiler water and conducting evaporative tests were installed together with a complete list of all instruments necessary to check boiler efficiency, stoker efficiency and combustion efficiency. A complete ultimate analysis of all the coal which will be fired as well as the proximate analysis will be made, to obtain information on these coals which the industry does not have at the present time.

George F. Klein, engineer for the Mackie-Clemens Fuel Co., is chairman of the committee in charge of the project and he states that the installation was prompted by the fact that in most of the schools throughout the state of Kansas, gas installations have been made, gas firing has generally won out over coal.

Kansas University is cooperating by assigning a Fellowship in engineering to conduct these tests. This Fellowship has been awarded to Hayden Zimmerman, a graduate from Georgia School of Technology and Mechanical Engineering of 1934.

GET THIS HOOK-UP DATA FOR EVERY VALVE NEED

FROM GOOD POWER HOOKUPS . . . TO GOOD VALVE PRACTICE
FOR BOILER CONNECTIONS...
Jenkins RECOMMENDS...
"A FEW OF THE JENKINS VALVES USED IN THIS HOOKUP"
IN VALVES Jenkins GIVES YOU EVERYTHING
Jenkins
RECOMMENDS
"GOOD VALVE PRACTICE"

SEND FOR YOUR COPY

There's no need to fumble or hunt when you look up a job in this Jenkins Power Hook-up Manual. You consult the equipment diagrams showing accepted practice for installing valves—and then check the various Bronze, Iron and Steel Valves which Jenkins recommends.

Every page is packed with sound engineering data, clearly illustrated and designed for easy reference.

You will want this book in your file—ready to help you on every valve problem and every valve replacement order. Just fill in the coupon for your copy.

Contents include Connections to:—
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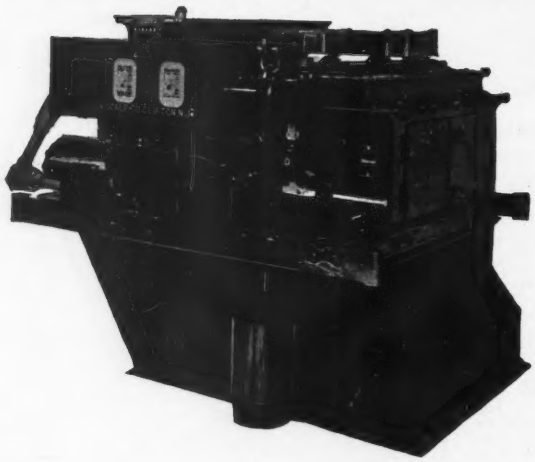
IN VALVES *Jenkins* GIVES YOU EVERYTHING

Increase BOILER EFFICIENCY *and lower* POWER COSTS *with the* RICHARDSON AUTOMATIC COAL SCALE



By comparing a month's coal bills with a month's output, you can *guess* at the power efficiency of your plant.

By estimating the day's coal consumption and comparing with the day's power sheets, you may "come pretty close". But in these days of high costs, a *guess* often represents the margin between profit and loss.

Richardson Automatic Coal Scales provide accurate and indispensable records for each boiler—each hour, shift, day, week and month—and assure highest possible operating economy.

Your fuel bill is a major cost item. If one boiler produces only 9 lbs. of steam instead of 10 lbs., that's a 10% loss!

By having a constant record and check of coal burned, up to any minute you take a reading, you will know what each boiler is producing, and will know what to do to save coal by avoiding waste, increase boiler efficiency and decrease your steam costs.

RICHARDSON

Atlanta Chicago Montreal Philadelphia
Boston Columbus New York San Francisco
Minneapolis Omaha Wichita

RICHARDSON SCALE COMPANY, CLIFTON, N. J.

Engineer— By Accident, Or Conviction

By L. M. DURYEE

A SPEAKER at an important engineering meeting recently said: "I admire, respect, and love our country. I believe in the American doctrine of freedom; in her true spirit of democracy; and in the integrity and unbounding loyalty of her founders. Though I was born abroad, I came to be a citizen of this great land through my own free will. I am, therefore, an American by conviction, rather than by accident."

"My son, you know", says the fond father, "is studying to be an engineer. I've always wanted him to take an interest in things like that—sort o' take after the Old Man in that respect, you know." Then the paternal thumbs are inserted in the parental vest, which bulges noticeably with pardonable pride.

Is it just possible, by chance, that the boy might become a famous lawyer, statesman, or merchant, were it not for this "guidance"—and possible intrusion—of the "Old Man"? Will he become a really successful engineer through this well-meant, but sometimes fatal, gratification of parental ego? Important questions, these, requiring careful, thoughtful, paternal attention!

Let's look for a moment into an example of the truth of this statement. Michael Pupin, father of long distance telephone transmission, was by birth and inheritance a Serbian shepherd. In the picturesque village of Ivdor, in what was formerly Austria Hungary, his parents reared him, when he was a boy, in the simple and wholesome art of the native villagers—that of farming. And since the most prized possessions of the village fathers were their oxen, young Michael quite naturally served his apprenticeship with his fellow herdsmen. During the long evenings on the Serbian plains, when all was still, Michael would signal to the distant shepherds by driving his knife-blade into the ground and tapping it. These impulses were carried through the dense ground for several miles with perfect clarity, and in this way, news of marauding bands of Roumanian cattle thieves was instantly transmitted to the waiting herdsmen. With this experience, in this most primitive system of wireless communication, Michael Pupin became profoundly interested in the wave motion of sound, and of light.

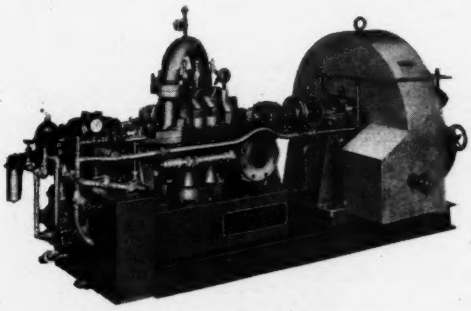
He came to America at the age of sixteen, with the blessings of his father and mother, in search of further knowledge. When he disembarked from his immigrant ship, he was completely ignorant of the language and customs of the new land. He obtained work in a New York factory almost at once. By studying nightly at Cooper Union Library, and by reciting from memory the famous speeches of great American statesmen, and

(Continued on page 140.)

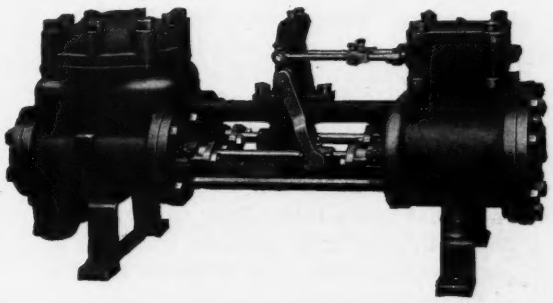
IF YOU'RE WATCHING POWER COSTS

DON'T OVERLOOK PUMPS

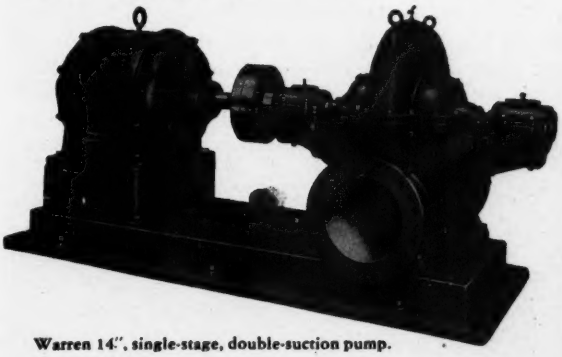
Original shop test efficiencies in centrifugal pumps often drop after a period of service, raise power consumption, offset many plant economies. Make a careful check into the power consumption and maintenance charges on all your pumps. And if you find costs out of line, check with Warren. Warren pumps have liberal clearances between impeller and case rings, extra heavy shafts, oversize bearings, carefully proportioned liquid passages to keep velocities within proper limits . . . *service-proven* design features that maintain original efficiencies over long periods . . . On replacements or additions, your Warren representative will gladly discuss your problems and submit recommendations. Write.



Warren 2", 4 stage turbine driven boiler feed pump. 600 lb. working pressures.



Warren "Realwear" chromized duplex piston pump.



Warren 14", single-stage, double-suction pump.

WARREN PUMPS

Centrifugal and reciprocating pumps for all power plant services—boiler feed, tank or pressure service, condenser, steam heat vacuum pumps.

WARREN STEAM PUMP COMPANY INC., WARREN, MASSACHUSETTS

BLAST *the air out of heating* COILS

WE DON'T recommend dynamite for air removal, but you do need to get air out of heating coils in a hurry. You use steam for the blasting when coils are drained by Anderson Super-Silvertops equipped with Thermal Air Eliminators. These snap action eliminators are wide open when steam is first turned on. Then the pressure forces the air out the exhaust in one swift "phoosh" and the eliminator snaps shut, preventing any steam loss. With that air removed, coils immediately fill with hot dry steam and heating begins at once—not hours later. Then the Anderson Super-Silvertop traps keep the coils free of condensate and entrained air for the balance of the heating cycle.

These extra-capacity traps save you heating time, installation time and maintenance expense. Find out more about them. Get the facts on instant air elimination. Write today for complete information or see them at booth No. 56 at the Heating and Ventilating Exposition.

THE V. D. ANDERSON COMPANY
1939 WEST 96TH ST. • CLEVELAND, OHIO

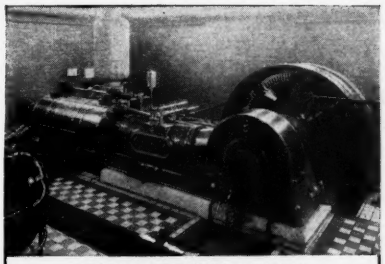
Super-Silvertop
STEAM TRAPS

by reading of the lives of the world's leading scientists, he made astounding progress. He went to Plymouth Church in Brooklyn and listened attentively to the memorable sermons of Henry Ward Beecher. He bought cheap gallery seats and watched the performances of great actors of his day, in order to learn pronunciation. He took advantage of every opportunity to improve himself. And in three short years after landing as an immigrant at the gateway to America, this former shepherd from Ivdor was admitted as a freshman to Columbia College in the City of New York, on scholarships in Latin, Greek, and in science! He had achieved, in three full years, what most American boys require two decades to accomplish. Fortunate, you agree, that he didn't follow in his father's footsteps? Yes. You see, his parents were quite open-minded about his career.

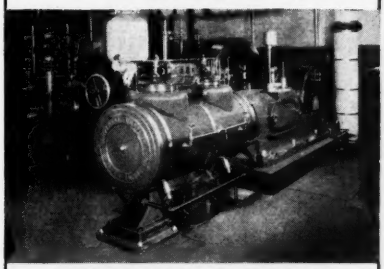
Twenty years passed, and Professor Pupin, teaching electrical engineering at Columbia, and working through the long hours of many a long night in his research laboratory, finally developed what is now so well known as the Pupin Loading Coil. By means of this invention it immediately became possible for telephone engineers to transmit the human voice over limitless distances, and without the use of booster stations. All this, from the brain of one who, had he been persuaded to follow in his father's footsteps, would have spent his life as a Serbian peasant, quietly farming in the fields of Ivdor! If this had occurred, the world would have been deprived of one of the great inventive minds of the present century. It is interesting to note that Dr. Pupin's autobiography is filled with convincing evidence that he became an engineer by *conviction,* first and last. That he was such an outstanding success in the field of science was due primarily to the co-operation of his parents, who recognized his unusual qualities and aided him in his career, despite many obstacles. They were grateful that a son had been born to them—simple peasant folk that they were —with such latent talent and with such definite plans for the future. So they did their utmost to see that his own desires in the matter of his education, were followed out.

So when, perhaps, the "Old Man" of the future, in speaking of his boy's career, puts the paternal thumbs into the parental vest and makes it bulge with pride, we hope he will profit by this homely philosophy. We hope he'll be able to say, and with truth, "Yes, sir, the boy's going to go to a technical school. You see, he's really first-class engineering material. Moreover, this is no mere guess. Vocational guidance laboratory tests confirm the boy's views—and mine, too. He's an engineer, I might say, by *conviction*—not by accident!"

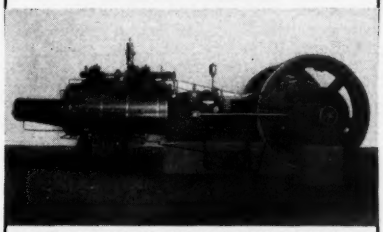
SUBMERGED red-and-green neon lights to guide insects to a surer death have been installed as the newest type fish-food lure in the field of Federal trout hatcheries. Although the use of light to attract flying insects to trout and other rearing ponds is nothing new, these novel, colored subsurface beacons, now in use at the Spearfish (South Dakota) Station, have never been tried out elsewhere, according to a field report from the Bureau of Fisheries, United States Department of the Interior.



SIDE CRANK "UNIVERSAL UNAFLOW" DIRECT CONNECTED

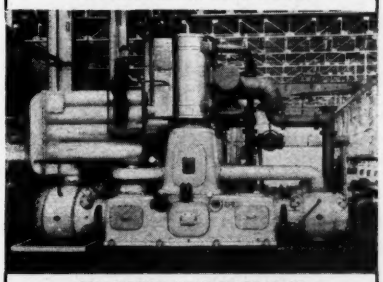


"UNIVERSAL UNAFLOW" DIRECT CONNECTED TO AMMONIA COMPRESSOR

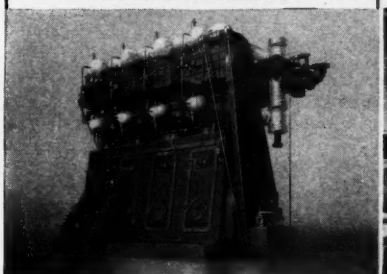


CENTER CRANK VARIABLE-SPEED MANUALLY CONTROLLED "UNIVERSAL UNAFLOW" FOR COMPRESSOR DRIVE

AUTOMATIC VARIABLE-SPEED "UNIVERSAL UNAFLOW" FOR COMPRESSOR OR HOT OIL PUMP DRIVE



TWIN VERTICAL UNAFLOW CYLINDERS MOUNTED ON AIR COMPRESSOR



SKINNER MARINE UNAFLOW STEAM ENGINE

For Generating Power—
For Driving Compressors,
Pumps, Blowers, etc.

SKINNER

HORIZONTAL OR VERTICAL

"UNIVERSAL UNAFLOW" STEAM ENGINES

The most complete line of poppet-valve unaflow steam engines in this country, and probably in the world, has been designed and built by this company. Eighteen different types of horizontal and vertical unaflow engines are available for stationary or marine service. Selection of the proper type of "the most economical steam engine ever built" may be made for your particular requirements.

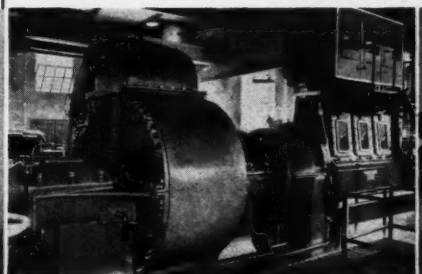
Maintained high economy of every SKINNER UNAFLOW ENGINE is assured by the use of permanently steam-tight poppet valves. Hundreds of installations have been paid for out of savings in fuel or in comparison with purchased power.

For generator drive, SKINNER "UNIVERSAL UNAFLOW" ENGINES are built in horizontal and multi-cylinder vertical types; horizontal type, for generators of 50 to 800-kw. capacity; vertical, 150 to 1500-kw.

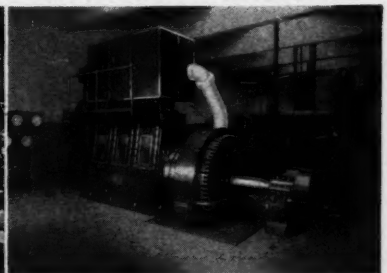
For compressors, pumps, blowers, etc., both constant-speed and variable-speed types are available. Patented sleeve-poppet-valve gear, for manual or automatic variable-speed control, maintains desired capacities or compressor pressures.

Literature and complete information on "UNIVERSAL UNAFLOW" ENGINES for your particular application will be forwarded on request.

SKINNER ENGINE CO., ERIE, PA.



AUTOMATIC VARIABLE-SPEED VERTICAL "UNIVERSAL UNAFLOW" FOR BLOWER DRIVE



DIRECT CONNECTED STATIONARY VERTICAL "UNIVERSAL UNAFLOW"

New Engineering Books

Applied Economics for Engineers, by Bernard Lester. Cloth bound, 6 by 9 in., 464 pages, published by John Wiley & Sons, Inc., New York city, 1939, price $4.00.

Although this book is presented in the form of a text book for engineering students, its content deals with the present problems of the industrial engineer in the practical application of economics. Throughout the entire 464 pages, Mr. Lester, an electrical engineer associated with Westinghouse Electric Mfg. Co. and lecturer at the University of Pittsburgh, has presented tables of statistics, curves of social and economic trends, and a fund of specific information on organization and management methods extremely helpful to the executive in the management of an industrial plant. The book is divided into 18 chapters dealing with the following subjects: Economics and the Engineer Principles and Methods of Planning; Human and Public Relations in Industry; Industrial Organization; Standards and Standardization; Principal Elements of Cost; Statistical and Accounting Methods; Requirements of the User; Problems of the Supplier—Development, Production, Purchasing; Market for Technical Products; Distribution of Technical Products; Functions of Organized Selling; Price and Price Policies; Engineer as a Citizen; Economic Studies. With a thorough index of topics discussed, the book is an extremely handy reference to secure information in rather condensed form on present-day practices in American industrial plants.

Thermodynamics for Chemical Engineers. By Harold C. Weber. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York City. Size 5½ by 9 in., 255 pp., cloth bound. Price $3.25.

Mechanical engineers deal primarily with the physical phases of thermodynamics, the conversion of energy from one form to another under steady flow conditions where high efficiency means the reduction of heat and frictional losses to the economical minimum. To many of these this book will open up new and broader avenues to the science which forms the basis of the power industry, for it is approached from the standpoint of the chemical engineer. He must be familiar with the entropy concept, so convenient for the mechanical engineer, and also with the analysis in terms of free energy, much more direct and convenient from the standpoint of the chemist whose work is largely concerned with chemical reactions, approximating at least, constant pressure and temperature conditions. These two methods of interpretation are correlated so that either may be used in the solution of a given problem as more convenient and appropriate for the particular conditions and requirements.

The problem arrangement is particularly interesting in that it is intended to impress the reader with the importance of fundamental therodynamics analysis and the fact that this analysis is independent of the particular material under consideration. Problems at the end of Chapter II can be solved in general mathematical expressions. Later the same problems can be solved for numerical answers for steam and perfect gases, and finally, for change of state in such functions as entropy, free energy and availability. The author is associate professor of chemical engineering at M.I.T.

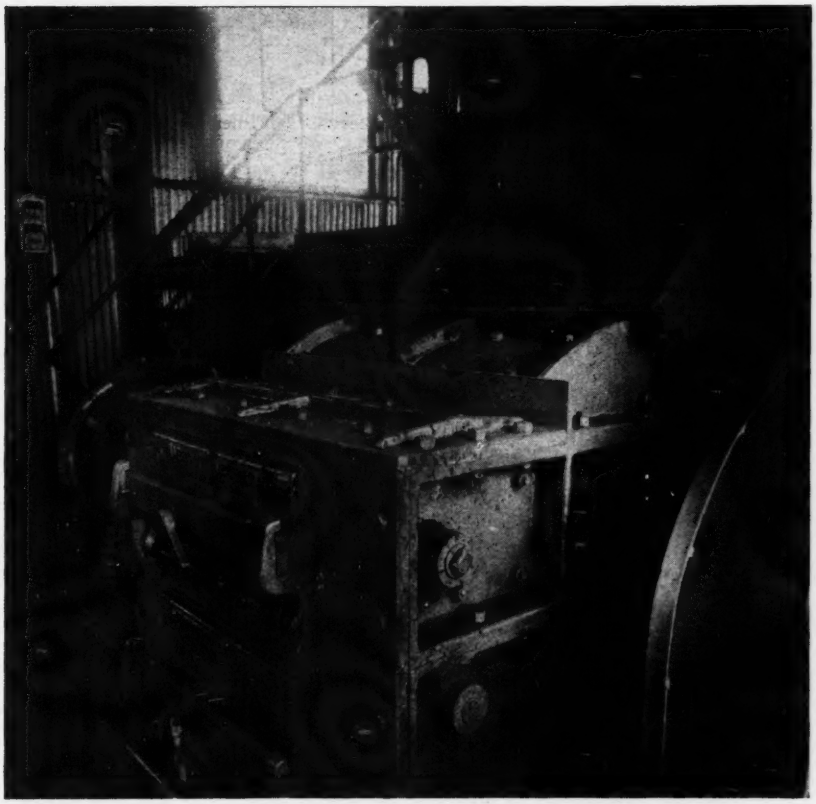
Manual of Ordinances and Requirements. Published by the Smoke Prevention Association, City Hall Square Bldg., Chicago, Ill. Size 6 by 9 in.; paper bound; 172 pp. Price $0.50.

This manual is the official publication of the Smoke Prevention Association and covers ordinances and requirements in the interest of air pollution, smoke elimination and fuel combustion. It includes the proceedings of the 33rd Annual Convention held June 13 to 16, 1939, at Milwaukee, Wis. (See Power Plant Engineering, page 554, August, 1939), with data on classification of solid fuels, the Stoker Manufacturers Association uniform stoker rating recommendations, suggested operating procedure for underfeed stokers, equipment and procedure of dust fall determination and instructions for burning low volatile coal in low pressure heating boilers.

THIS BOILER ROOM NEWS TICKER gives the answer NOW!
YESTERDAY'S MARKET QUOTATIONS are no good today. Similarly, facts about boiler and furnace conditions must be fresh—and accurate.
There is instant response between the necessity for correcting combustion conditions and the actual adjustment when Hays Automatic Combustion Control is on the job. Also the results of the adjustment are electrically recorded so there is no time lost in getting the facts before the boiler room attendants.
Hays control not only effects surprising economy in fuel but maintains the entire steam plant at the peak of efficiency. Steam pressure is maintained constant under wide variation in load.
There is a Hays engineer-representative near you to inspect your steam plant without obligation and advise on cost and effectiveness of automatic combustion control. Much general information may also be freely obtained by writing 910 Eighth Avenue, Michigan City, Indiana
Hays also makes draft gages, CO_2 meters and portable combustion testing instruments.
The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

PREPARING COAL FOR BETTER COMBUSTION with an "AMERICAN"

More uniform and efficient sizing of coal results in savings for the Lynn, Massachusetts, power plant of the Lynn Gas & Electric Company. Stone & Webster Engineering Corporation, Consulting Engineers.



. . . at LYNN GAS & ELECTRIC CO.

The recent installation of an American Ring Crusher in this plant has resulted in better combustion through more economical and effective coal preparation.

Shown here is a view of the "American" Crusher serving this plant. The building shown houses the crusher which is used in the coal handling system to crush both gas and steam coal. From the preparation house, coal is conveyed to the boiler house ready for feeding to boilers.

Savings from the use of American Ring Crushers vary from 2½ to 8% in fuel. Crushing costs, including fixed charges average less than 2c per ton. Think what savings such as these can mean in your power costs—then investigate!

Our engineers will gladly furnish specific operating data for your analysis. Ask us for details.

BETTER COAL PREPARATION CENTERS IN THIS EXCLUSIVE "AMERICAN" FEATURE

In the "American", coal is actually split rather than crushed. This result is achieved through a reversible manganese steel Shredder Ring—an exclusive "American" development which makes it possible to size coal properly for stoker or pulverized fuel firing by a simple adjustment.

AMERICAN PULVERIZER COMPANY 1429 Macklind Avenue St. Louis, Missouri

ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS

A. C. Network Operation 1936-1937. A Report of the Transmission and Distribution Committee of the Edison Electric Institute. Publication No. G1. Published August 1939 by the Edison Electric Institute, 420 Lexington Ave., New York, N. Y. Price 80 cents to members and their employes. $2.00 to non-members, U. S. A. $2.10 to foreign countries.

This report is compiled from data submitted by 69 companies operating 222 network areas in 121 cities or localities. These data have been analyzed, in general, on two bases, i. e., in relation to per cent of total peak load and per cent of reporting localities. The total peak load served by low voltage a. c. networks in 1937 showed an increase of 37.6 per cent over that reported for 1935. The total reported installed transformer capacity showed an increase of 27.4 per cent for the same period, which results in a continuation of improvement in load transformer capacity ratio.

Ignition-Quality Rating of Diesel Fuels. By Jasper S. Chandler. Published as Bulletin No. 47 of the Engineering Experiment Station, Pennsylvania State College, State College, Pa. Size 6 by 9 in., 80 pages, cloth bound. Price $0.75.

This bulletin is the report of an experimental investigation of seven fuels used in nine commercial engines of various types and sizes. While the ignition-quality ratings of commercial engines was found to differ not more than an average of 1.56 cetane numbers among themselves, they did show an average of 3 cetane numbers higher than the laboratory ratings on the C.F.R. engine. The engine type was found to have a greater effect on the rating than the particular technique used to determine it. The correlation found is said by the author to be distinctly encouraging. Pennsylvania State College Laboratories have long been interested in Diesel fuel testing problems and the earlier work of Professor Schweitzer is well known. Mr. Chandler, who is a Fellow in Research Engineering at the Engineering Experiment Station, writes with a full background of the problem and the bulletin warrants close study by those interested in this phase of internal engine design, performance and operation.

The ABC of Aviation. By Victor W. Page. Published by The Norman W. Henley Publishing Co., 2 West 45th St., New York city. Size 7¾ by 5 in.; cloth bound; 436 pp. Price $2.50.

While this book is somewhat out of the field of power plant engineering it is an excellent general instruction book on the engineering features of modern aviation with a concise and comprehensive chapter on engine types and inspection. The chapter devoted to this phase covers the essential requirements of the aeroplane power plant, piston displacement and power output of typical engines, power requirements, classes of aviation engines, air vs. water cooling, superchargers, Diesel engines, general engine inspection routine and engine troubles.

Patent Fundamentals. By Adelbert Schapp. Published by The Industrial Press, 148 Lafayette St., New York City. 176-pp.; size 5½ by 8½ inches. Price $2.

Intended particularly to aid the inventor in securing a correct understanding of the problems involved in obtaining proper patent protection, the treatise explains, in non-technical language and by practical examples, the underlying principles of true invention, procedure in obtaining patent protection, drafting effective claims, making assignments, issuing licenses and, in brief, how to protect the invention and the inventor. Information on trademarks and copyrights, design patents, prints and labels are included together with illustrations of the different conditions under which these protective measures become available. It is written in textbook style and is adapted for use in educational institutions having courses dealing with the fundamentals of patent law.

Fluid Flow Measurement by Head Type Metering Elements. By F. C. Stewart and J. S. Doolittle. Published by The Instruments Publishing Co., Pittsburgh, Pa. Size 8½ by 12 in.; paper bound; 24 pp. Price $1.00.

This is a comprehensive and concise technical treatment of the measurement of liquids and gases with orifices, nozzles, Venturi tubes, etc. Both authors are professors at Pennsylvania State College.

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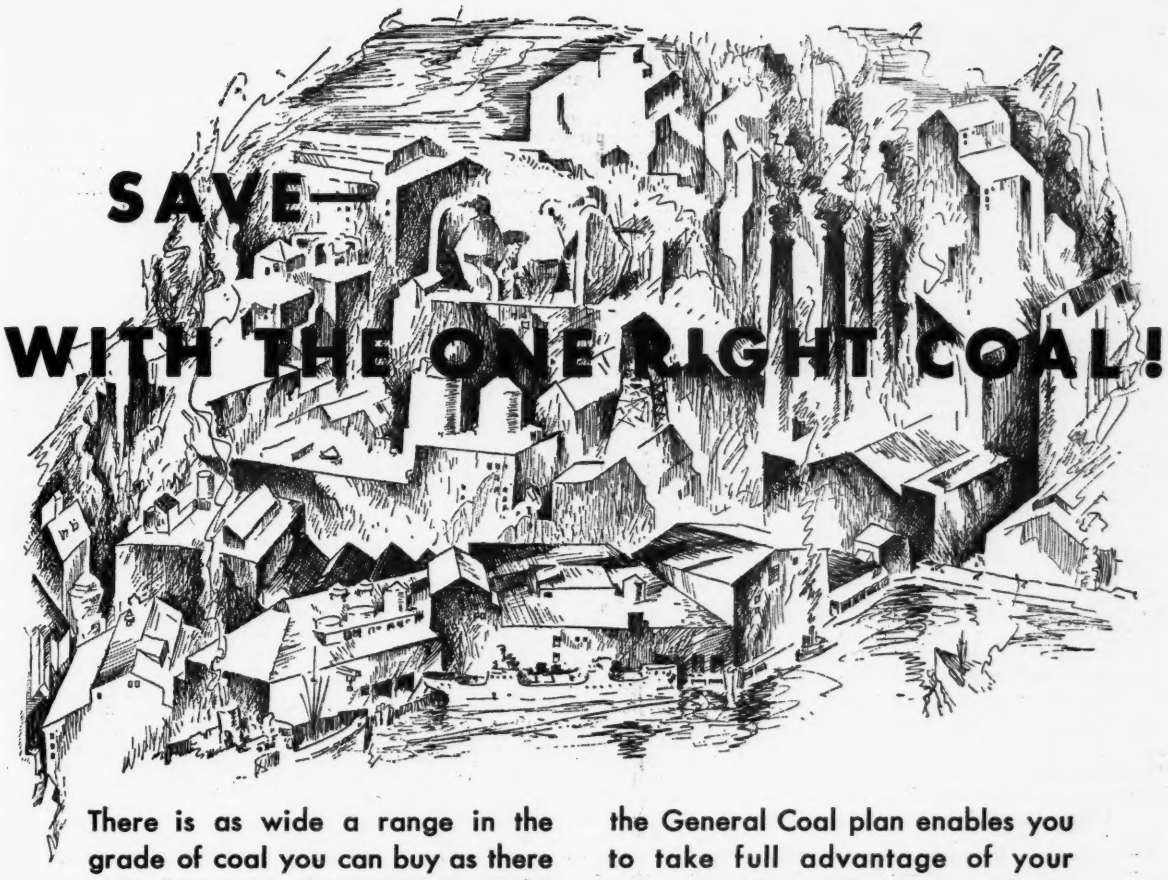

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Diesel Engineering Handbook. Editor, L. H. Morrison. Published by Diesel Publications, Inc., 192 Lexington Ave., New York city. Size 5½ by 9 in.; flexible fabricoid binding; 992 pp. Price $6.00.

While following along the general lines of earlier editions, this new De Luxe Edition has been almost entirely rewritten as a new book in order to take account of the recent development in Diesel design and application. There are 30 chapters, a few of which are devoted to engineering fundamentals, necessary thermodynamics and the Diesel heat cycle. In the balance of the chapters the component parts of these engines are discussed from the standpoint of commercial design to meet the requirements of operation and maintenance. Some of these parts include: fuel-injection systems, frames and cylinders, pistons and rings, bearings, shafts, cylinder heads, foundation isolation, governors, air systems, supercharging, exhaust systems, starting systems, voltage regulators, couplings, clutches, etc.

American Diesel Engines. By L. H. Morrison. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York city. Size 6 by 9 in.; 482 pp.; cloth bound. Price $5.00.

The second edition of this book was necessitated by the great change which has taken place in the Diesel engine field in the nine years since the first edition appeared. It is a comprehensive handbook to help the engineer choose the Diesel engine best suited to his need. The history and development of the Diesel is traced briefly; the fundamental principles and component parts of the engine's system outlined; and the engines themselves discussed in three main divisions: the air-injection Diesel; the heavy duty mechanical-injection Diesel and the high speed Diesel. The book describes in detail every American-made engine and includes a great deal of practical information on the installation, testing and operation of the engines.

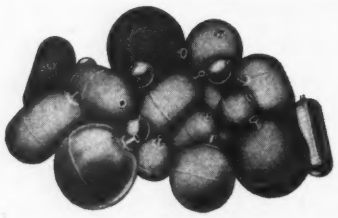
Internal Combustion Engines. By Lester C. Lichty. Published by McGraw-Hill Book Co. 330 W. 42nd St., New York city. Size 6 by 9 in.; 589 pp.; cloth bound. Price $4.50.

While this is listed as the 5th edition of a book first written by the late Robert L. Streeter in 1915, with subsequent editions and revisions under joint authorship, it is in effect an entirely new book written entirely by Professor Lichty and the similarity between editions is confined almost entirely to the general procedure and arrangement of material.

Theoretical principles are developed in relation to their application to the design and operation of internal combustion engines. The analysis of combustion and thermodynamic processes is much simplified by the direct use of the general energy equation, and its principles made simple by the use of combustion charts of a usable size which appear in the last part of the book. Advances in fuels and changes in their chacteristics have been taken care of and the modern problem of fuel injection and detonation covered in some detail. Inasmuch as it was intended as a textbook for the usual undergraduate college course the text includes a number of problems and exercises out to serve as a check for the student or reader understanding the application of the principles set forth in each chapter. The author is associate professor of mechanical engineering at Yale University.

The Engineering Experiment Station of the University of Illinois, Urbana, Ill., recently published three bulletins. Circular No. 39 includes 19 papers presented at the Fifth Short Course in Coal Utilization held at the University May 23 to 25, 1939, contains 173 pp. and sells for 50 ct. Reprint Series No. 15, Stress, Strain, and Structural Damage by Herbert F. Moore, is reprinted from the Proceedings of the A.S.T.M., has 24 pp. and sells for 15 ct. Bulletin Series No. 316, The Effect of Range of Stress on the Torsional Fatigue Strength of Steel, by James O. Smith, is the report of an investigation made by the author, contains 35 pp. and sells for 45 ct.

Material Specifications for Pumps—The Committee on Material Specifications of Hydraulic Institute, 90 West Street, New York, N. Y., has prepared specifications covering cast materials generally used in the manufacture of pumping equipment for the petroleum industry. A specification covering bolt and nut materials for similar service has also been prepared. Copies of this 16 pp. book can be obtained from the Institute. Price 25 cents.



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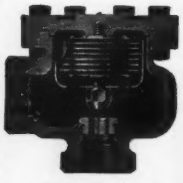

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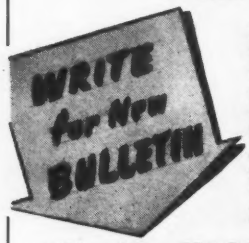

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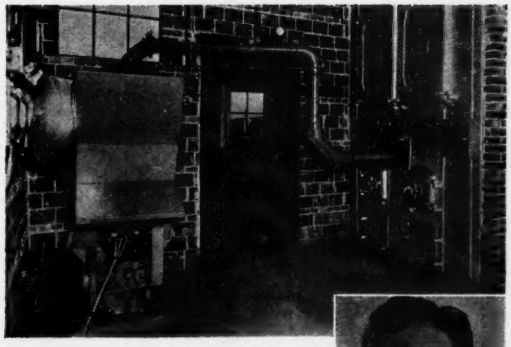

Sam Bronstein, manager, Pueblo By-Products Co., Pueblo, Colorado. *Above:* Iron Fireman Pneumatic Spreader installed in Pueblo's HRT boiler.

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Power Plant Construction News

Alaska, Fairbanks—Construction Quartermaster, United States Army, Washington, D. C., plans steam-electric power plant at new air base at Fairbanks, for light, power and central-heating service. Also will build a pumping station and other utility structures. Entire project will comprise a large group of buildings for which an appropriation of $3,600,000 has been arranged.

Calif., Los Angeles—Los Angeles Water and Power Bureau, 205 South Broadway, has plans maturing for new three-story electric equipment building for repairs, inspection, reconditioning, etc., to be 120x180 ft., located at 1530 St. John Street. Complete electric power equipment for operation will be installed, including crane, conveyors and other handling apparatus. Erection is scheduled to begin early in 1940. Cost about $350,000.

Ga., Winder—National Furniture Co., plans installation of power equipment in connection with rebuilding of portion of local plant recently destroyed by fire. Loss reported over $75,000.

Ga, Savannah—Savannah Electric & Power Co., has plans for expansion and improvements in local Riverside steam-electric generating station, including installation of new high-pressure boiler unit with rated capacity of 100,000 lb. of steam per hour, and auxiliary equipment. Cost estimated about $300,000. Proposed to begin work in the spring.

Ill, Chicago—Commonwealth Edison Co., 72 West Adams Street, has plans maturing and will begin work early in 1940 on addition to Northwest steam-electric generating station, California and Roscoe Avenues. Equipment will be installed for increased capacity. Sargent & Lundy, Inc., 140 South Dearborn Street, is consulting engineer.

Ind., Roby—American Maize Products Co., 135 South LaSalle Street, Chicago, Ill., plans installation of electric power equipment in new additions to starch manufacturing plant on Sixth Street, Roby, comprising four one and multi-story units, to provide large increased capacity. Work will begin at once. Entire project will cost close to $250,000. Sargent & Lundy, Inc., 140 South Dearborn Street, Chicago, is consulting engineer.

Iowa, Waukon—Common Council has engaged Hubbard Engineering Co., 80 East Jackson Boulevard, Chicago, Ill., consulting engineer, to make surveys and estimates of cost for new municipal electric power plant. Proposed to use Diesel engine-generating units and accessories.

La., Shreveport—International Harvester Co., 180 North Michigan Avenue, Chicago, Ill., plans installation of electric power equipment in new factory branch at Greenwood and Mansfield Roads, Shreveport, where 3-acre tract of land was acquired recently. Entire project is reported to cost about $200,000. Proposed to begin erection in 1940. Company engineering department, Chicago address noted, is in charge.

Mich., East Lansing—State Agricultural Department, Capitol Building, Lansing, has preliminary plans for one-story addition to power plant at Michigan State College, East Lansing. Cost estimated close to $150,000, including equipment installation.

Mich., Escanaba—Upper Michigan Light & Power Co., Escanaba, has tentative plans under advisement for extensions and improvements in generating station, including installation of additional equipment. Cost estimated close to $300,000.

Minn., Rushford—City Council has authorized plans for new municipal electric light and power plant, to cost about $80,000. Proposed to use Diesel engine-generating units and accessories. Bids are scheduled to be asked early in 1940. Ealy J. Briggs, 1957 University Avenue, St. Paul, Minn., is consulting engineer.

Minn., St. Cloud—Northern States Power Co., 15 South Fifth Street, Minneapolis, Minn., has plans in progress for new multi-story addition, 60x120 ft., to steam-electric generating plant at

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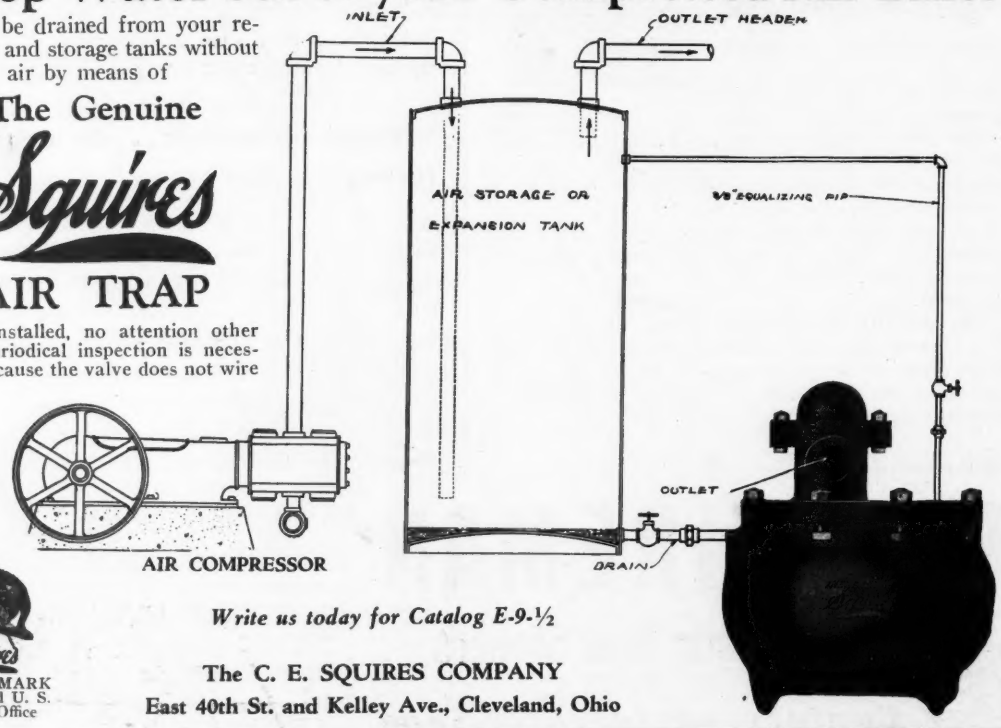

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St. Cloud, to be equipped for increased capacity. Installation will include new 7500-kw. generator and accessories, boiler unit and auxiliary equipment. Cost estimated close to $600,000. Work will be placed under way early in the spring.

Miss., Jackson—Great Southern Box Co., Inc., New Orleans, La., plans installation of power equipment in new one-story branch plant, 70x250 ft., at East Jackson, where site has been acquired, for production of corrugated paper boxes and containers. A boiler house is planned. Entire project will cost close to $150,000. Proposed to begin work soon.

N. Y., Buffalo—Allegheny-Ludlam Steel Corporation, Oliver Building, Pittsburgh, Pa., plans installation of electric power equipment in connection with expansion and improvements in branch stainless steel mill on South Elmwood Avenue. Entire project is reported to cost over $500,000, and will be carried out during 1940.

N. C., Kinston—City Council is considering expansion and improvements in municipal power plant, waterworks station and water system. Cost estimated about $300,000. It is proposed to arrange a bond issue in that amount.

Ohio, Alliance—Ohio Public Service Co., Hanna Building, Cleveland, Ohio, has plans under way for expansion and improvements in steam-electric power plant in Lake Park district, Alliance, including modernization of turbine-generator unit, installation of coal and ash-handling machinery and other equipment. Cost estimated about $150,000. Proposed to begin work early in 1940.

Ohio, Cincinnati—Cincinnati Butchers' Supply Co., 2145 Central Parkway, manufacturer of refrigerators, store fixtures, etc., plans installation of electric power equipment in connection with establishment of new plant at former local works of Worthington Pump & Machinery Corporation, Vine Street, recently acquired, to be modernized and improved for such purpose. A boiler house will be built. Entire project will cost about $125,000. George McDonald, Fountain Square Building, is architect.

Ohio, Middletown—Inland Container Corporation, 700 West Morris Street, Indianapolis, Ind., plans installation of electric power equipment in one-story addition, 140x200 ft., to branch corrugated paper box and container plant on Nelbar Street, Middletown, for which superstructure will begin at once. Entire project estimated to cost close to $75,000.

Ohio, Sabina—City Council has engaged Fosdick & Hilmer, Union Trust Building, Cincinnati, consulting engineers, to prepare plans for extensions and improvements in municipal power plant and waterworks station, including installation of additional equipment. Bond issue of $60,000 has been approved. Proposed to ask bids soon.

Pa., Williamsport—Lycoming Mfg Co., division of Aviation Mfg. Corporation, 420 Lexington Avenue, New York, N. Y., plans installation of electric power equipment in connection with expansion and improvements in airplane engine-manufacturing works, including erection of new units. Entire project will cost over $300,000.

Texas, Ingleside—Humble Oil & Refining Co., Humble Building, Houston, Tex., plans installation of power equipment in connection with expansion and modernization in oil refining plant at Ingleside. Work will be placed under way at once. Entire project is reported to cost approximately $2,500,000.

W. Va., Beechbottom—West Penn Power Co., West Penn Building, Pittsburgh, Pa., will complete plans soon for expansion in steam-electric generating plant at Beechbottom, known as Windsor station and operated jointly with Ohio Power Co., Newark, Ohio. Work will include installation of new 60,000-kw. turbine-generating unit and auxiliary equipment. Line extensions will be made. Equipment awards will be made at early date. Work is scheduled to begin in 1940.

Wis., Fennimore—City Council has plans maturing for new municipal power plant, using Diesel engine-generating units and accessories, and will take bids soon for equipment. Cost estimated about $70,000. George H. Leiser, Portage, Wis., is consulting engineer.

Wis., Madison—Fauerbach Brewing Co., 651 Williamson Street, plans installation of electric power equipment, conveyors and other mechanical-handling apparatus in new one-story addition at foot of Blount Street, to be used as a bottling division. Work is scheduled to begin early next spring. Cost about $170,000. Balch & Lippert, 16 North Carroll Street, are architects.

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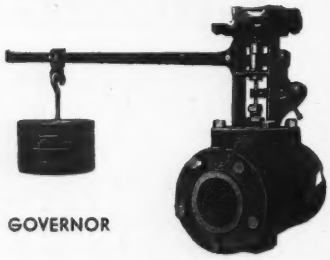

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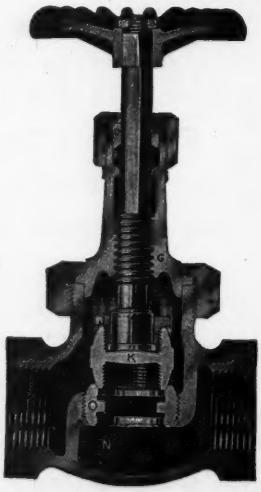

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